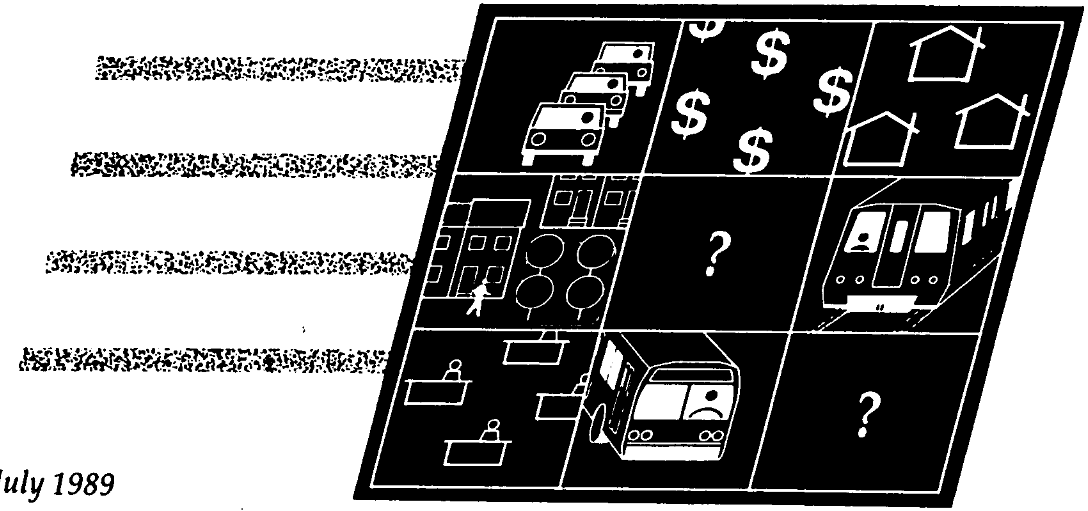
ALTERNATIVE SCENARIOS:
Analysis and Evaluation



July 1989

Volume 2

Montgomery County
Comprehensive Growth Policy Study

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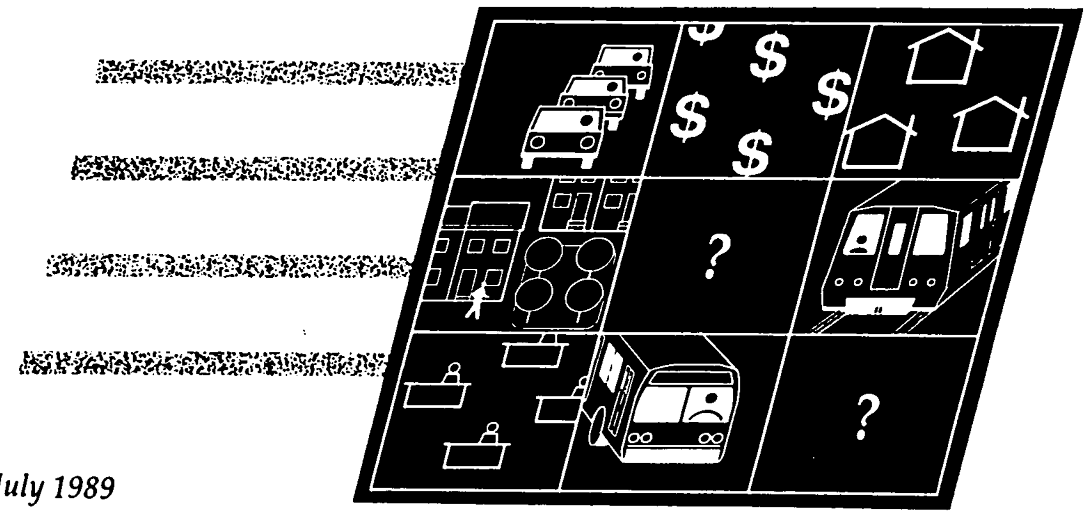

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Montgomery County
Comprehensive Growth Policy Study

ABSTRACT

Title: Comprehensive Growth Policy Study
Volume 2. ALTERNATIVE SCENARIOS: Analysis and Evaluation

Author: Montgomery County Planning Department
The Maryland-National Capital Park and Planning Commission

Subject: Description of assumptions, methods, and results of constructing and testing alternative scenarios for future growth

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Abstract: This document describes how a set of alternative future growth scenarios were constructed, involving three major components: (1) quantitative job and housing totals; (2) spatial land use patterns; and (3) incentives to induce a shift from automobile to transit behavior patterns. It describes two computerized impact assessment models, called, respectively, TRAVEL and FISCAL, and the results of applying these simulation models to a number of alternative growth scenarios. This volume is part of a larger set that comprises the complete study.

The Maryland-National Capital Park and Planning Commission

The Maryland-National Capital Park and Planning Commission is a bi-county agency created by the General Assembly of Maryland in 1927. The Commission's geographic authority extends to the great majority of Montgomery and Prince George's Counties: The Maryland-Washington Regional District (M-NCPPC planning jurisdiction) comprises 1,001 square miles, while the Metropolitan District (parks) comprises 919 square miles in the two counties.

The Commission has three major functions:

(1) the preparation, adoption, and, from time to time, amendment or extension of the General Plan for the physical development of the Maryland-Washington Regional District;

(2) the acquisition, development, operation, and maintenance of a public park system; and

(3) in Prince George's County only, the operation of the entire County public recreation program.

The Commission operates in each county through a Planning Board appointed by and responsible to the county government. All local plans, recommendations on zoning amendments, administration of subdivision regulations, and general administration of parks are responsibilities of the Planning Boards.

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The Alternative Scenarios volume of the Comprehensive Growth Policy Study is subject to further minor changes, pending final checks on cost estimates and other references

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Chapter 1

Alternative Scenarios

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CHAPTER 1: ALTERNATIVE SCENARIOS

Section A: The Economic Scenarios

This Study is not a plan. It is intended to illustrate the nature of the land use and transportation choices facing the County.

The Study develops economic and geographic scenarios that will help the County Council and the public understand how different levels of growth, locations of growth, and forms of transportation will affect the County's budget, congestion, and built environment. It begins with four alternative economic growth scenarios, expressed in terms of countywide totals for jobs and housing units. The economic scenarios combine two different levels of increase in jobs and housing to produce four alternatives, called: SLOW, FAST, JOBS, and HOUSING. A horizon year of 2020 was chosen for these scenarios because of the time it takes to get major transit systems in place. In addition, reasonable yearly differences between growth in jobs and growth in housing would not result in sufficiently different scenarios within a shorter time period.

The levels of growth in housing and jobs for the economic scenarios were chosen to represent two dimensions of growth: first, the outer limits of what the County might want to achieve in increasing or decreasing the rate of growth over thirty years; and second, the outer limits of how the County might want to vary the ratio of jobs to housing in increasing or slowing growth. The combination of choices for rate of growth and J/H ratio resulted in the four economic scenarios, which are described below.

In addition, a TREND Benchmark was developed, which reflects continuation of current transportation and land use policies, and continued growth in accordance with the COG Round IV forecast. It was developed to provide a point of reference for the other scenarios.

The total numbers of jobs and households for the economic scenarios are listed and are plotted graphically against each other in Figure 1.1.

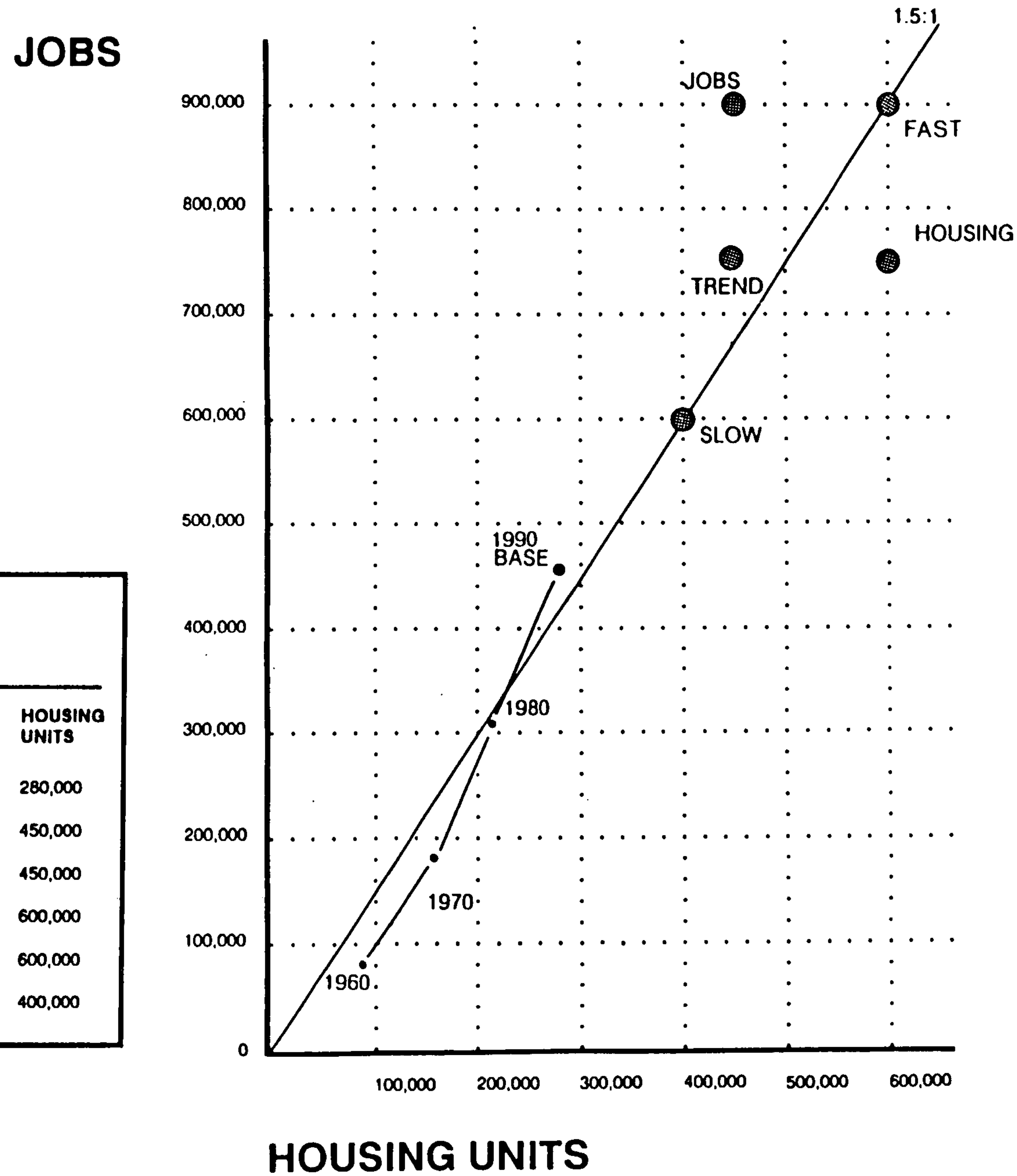
The straight diagonal line in Figure 1.1 indicates the current number of workers per household in the County, which is about 1.5. For the purposes of this Study, jobs and housing in the County would balance, by definition, when the County had 1.5 jobs for every household. It should be noted that the Planning Department's Research Division feels that, based on the demographic model, the J/H ratio for the County has peaked and will be declining to somewhat below 1.5 in the future as the County's work force ages.

Many people still commute out of and into the County for jobs, although the ratio of jobs to housing nearly equals the number of workers per household in the County. Forty percent of County residents work outside

FIGURE 1.1

SCENARIOS: Control Totals and Comparison to Past Growth

CGPS COUNTY CONTROL TOTALS	J/H RATIO	JOBS	HOUSING UNITS
1990 BASE	1.6	455,000	280,000
TREND	1.7	750,000	450,000
JOBS OVER HOUSING	2.0	900,000	450,000
HOUSING OVER JOBS	1.3	750,000	600,000
FAST & BALANCED	1.5	900,000	600,000
SLOW & BALANCED	1.5	600,000	400,000



the County, over half of them in the District. Many lower wage workers have no choice but to commute long distances by car to jobs in the County, due to the lack of affordable housing.

It would be helpful to evaluate the balance between County workers at given income levels and the availability of housing affordable in the County for each group of workers by income range. Unfortunately, data to evaluate this is not readily available and has thus far prevented staff from making the TRAVEL model sensitive to changes over time in the income-stratified job/housing balance. Work at the Metropolitan Washington Council of Governments, beginning this year at Montgomery County's request, will begin to address this, but further data collection resources are needed to get to the heart of the matter.

As noted above, these four scenarios are intended to illustrate significantly different economic futures for the County. The SLOW scenario tests the effect of restraining both employment and housing growth. Since an important objective of this scenario as defined by the County Council is to increase the supply of housing relative to employment, this scenario assumes that jobs will total 600,000, a 150,000 reduction from the TREND scenario total of 750,000. Households, in contrast, are only reduced by 50,000, from 450,000 to 400,000.

At the other end of the spectrum, the FAST scenario tests the effect of pursuing policies that dramatically stimulate both employment and housing growth. Under this scenario jobs will total 900,000 and households will total 600,000.

The JOBS scenario tests the implications of pursuing policies that dramatically stimulate employment growth, but that do not alter the course of the TREND scenario projection of 450,000 households. The jobs total 900,000, the same as for the FAST scenario. In this scenario there are two times as many jobs as households, or a J/H ratio of 2.0. This scenario represents an outer limit for the number of jobs relative to the number of households in the County. It is unlikely that a suburban area like Montgomery County would have a mix of jobs and housing that would result in a J/H ratio greater than 2.0. The scarcity of housing and, therefore, workers, would limit the attraction of new jobs. (See, however, discussion of the VAN geographic scenario.)

In contrast to JOBS, the HOUSING scenario tests the effect of pursuing policies that dramatically stimulate housing growth, but that do not differ from the TREND scenario projection of 750,000 jobs. The households total 600,000, the same as for the FAST scenario. The HOUSING scenario yields a J/H ratio of 1.25. This also probably reflects an outer limit. It is unlikely that developers would continue to develop new homes in the face of very low job growth, because the market for those homes would be limited.

As noted earlier, the TREND Benchmark, which reflects continuation of current transportation and land use policies, and continued growth in accordance with the COG Round IV forecast, was developed to provide a

point of reference for the other scenarios. Jobs total 750,000 and households total 450,000. The COG Round IV Intermediate forecast for households has been projected to 2020 and increased to reflect some relaxation of current zoning constraints for housing. Under current zoning, not enough land is zoned for housing at high enough densities to permit 450,000 households. The COG Round IV Intermediate forecast constrained housing as build-out of zoning for housing approached.

The TREND Benchmark yields a J/H ratio of 1.67, larger than any other J/H ratio experienced to date in the County, implying that the balance between the number of jobs and the number of households will tilt even further in the direction of jobs unless constrained by zoning and growth policy administration.

The amount of growth in jobs and housing assumed in the different scenarios might appear unrealistic at first glance. It is useful to put these amounts in perspective.

Figure 1.2 compares household and job growth for the last thirty years to the growth in households and jobs assumed in the scenarios for the next thirty years. As it indicates, the scenarios are not significantly out of proportion with past experience. Different observers may disagree about whether the County should have grown as fast as it did in the past. The purpose of the present comparison is not to make a value judgment, but only to begin to give a feel for the scale of change the scenarios imply.

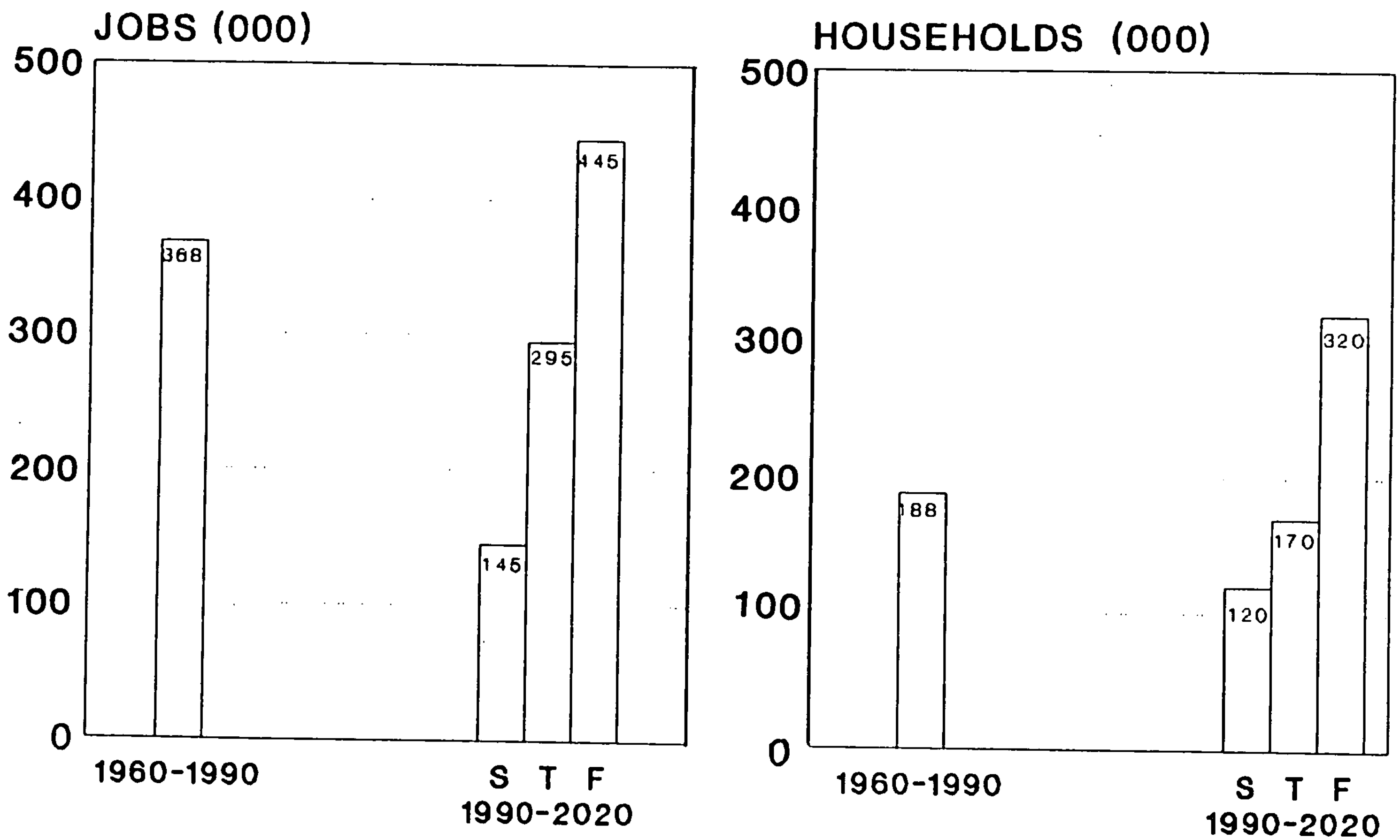
Section B: Geographic Scenarios

In addition to the four economic scenarios, expressed in terms of total jobs and housing units, three alternative geographic scenarios were developed, called AUTO, VAN, and RAIL. This section outlines the principles used to develop these geographic scenarios, which are discussed in more detail later.

The AUTO scenario reflects continued dependence on lone occupant vehicle (LOV) commuting. Additional transportation capacity would come primarily from the build-out of the Master Plan of Highways. Jobs and housing locations would be consistent with current plans and zoning; contained within the broad outlines of the Wedges and Corridors plan, but not excessively concentrated.

The VAN scenario reflects reliance on development of a network of lanes for buses and cars with three or more passengers. It increases transportation capacity by increasing vehicle occupancy levels. While the most visible use of such facilities is by high occupancy vehicle (HOV) cars, the greatest increase in person trip capacity usually comes from buses. It was for this reason that the term HOV scenario was rejected in favor of VAN scenario. The latter gives a better sense of the mix of vehicle types likely to be used by riders on an HOV facility. Jobs and housing locations would be clustered to a greater degree within the Wedges and Corridors outline to be better served by these new HOV and bus routes.

FIGURE 1.2 Montgomery County Past Growth 1960-1990 Compared to CGPS Scenarios



KEY: **S**=SLOW **T**=TREND **F**=FAST

The RAIL scenario relies on transit, primarily light rail, to alleviate congestion. The transit networks were developed to maximize network connectivity. The network connectivity principle suggests that by connecting the largest possible combination of origins and destinations it is possible to capture the largest ridership and the largest mode shift out of LOVs.

To make this transportation system practical, jobs and housing locations are concentrated within the Wedges and Corridors outline in key nodes served by rail line stations and transfer points.

Section C: Level of Detail

To use the traffic and fiscal assessment models, it is necessary to combine an economic scenario with a geographic scenario to form a composite "geo-economic" scenario. The total number of jobs and housing units in an economic scenario must be broken down into many smaller clusters and assigned to hundreds of geographical sub-areas. The assignment of these quantities must bear some reasonable relationship to the transportation network that forms the skeleton of the geographic scenario. Further assumptions also must be made about the operational characteristics of these transportation networks.

For example, to make cost and congestion estimates, each transit line had to be assigned defined headways (times between buses or between trains) and numbers of cars per train. At the same time, each transit stop required estimates of the number of jobs and numbers of households within walking distance of each stop.

As a result of the amount of detail required, development of the transit proposals took more time than expected. The result was to limit the RAIL scenario to essentially one basic rail network. Further work could evaluate other rail links and refine the implications of this conceptual land use pattern.

Similar problems developed with the VAN scenario, but for different reasons. HOV facility designs are being developed rapidly, but the concept is only about ten to fifteen years old. Most HOV facilities are extremely new. For example, there are only three places in the country, Santa Clara County in California, Houston, and Seattle, that have done any work on an interconnected system of HOV facilities. As a result of the newness of HOV, there is very little experience available to use in designing a system. Aside from the details required for the TRAVEL model to use in estimating costs and congestion, simply defining the system was a lengthy process because of the sheer numbers of possibilities. As a result, the VAN geographic scenario was combined with only the FAST economic scenario. Other combinations can be tested in the future as time and need determine.

Section D: Transit Incentives and Enhancements (TIE)

Whether or not someone chooses to drive alone, carpool, take Metro, or ride a bus depends on a large num-

ber of considerations in addition to the location of the transportation network and the location/density of the land uses. For example, it is generally accepted that when free parking is provided by employers, people are more likely to drive. Whether there are sidewalks or muddy shoulders on the way to the bus stop, and whether, at the other end of the trip, the bus stop is a long walk from the shopping mall across a rainy parking lot are also factors.

Recognizing this fact, the composite geo-economic scenarios also were tested against three different levels (i.e. weak, moderate, and strong) of what is called the Transit Incentives and Enhancements (TIE) package. The term refers to a set of actions that government could take to encourage the use of transit. They include such items as increases in parking fees and auto cost, decrease in transit fare levels, convenience of pedestrian and bicycle access, etc.

Section E: Optimization

This Study consciously keeps the AUTO, VAN and RAIL scenarios separate in order to illustrate their differences.

The County will almost certainly use a mixture of transportation systems to meet future needs. It is unlikely that it would rely exclusively on either highways, light rail, or HOV. This Study, however, focuses separately on highways, light rail, and HOV and major public policies that can influence their ridership. It focuses on highways to illustrate how far we can get in relying on them. It focuses on light rail and HOV because they are likely to be the major types of new additions to the County's transportation capacity. It focuses on policies that affect mode choice because these have a substantial impact on the cost effectiveness of any transportation investment.

The Study does not attempt to find the best possible combination of highways, light rail, and HOV facilities and the optimum land use pattern that accompanies it. The purpose of the Study is not to provide a plan. It is to illustrate the nature of the choices the County can make. In particular, in terms of transportation, it is to show the advantages and disadvantages of highways, light rail, and HOV and how they affect land use and are affected by land use. The Study distinguishes as clearly as it can between the three transportation types, within the limitations of decisions and commitments already made or very likely to be made.

It is important to understand that the transportation networks tested have not yet been fine tuned to include the possible deletion of some individual roads, light rail lines, or HOV/bus facilities that might not carry sufficient demand to justify the cost of the investment.

The transportation facility networks used in the VAN and RAIL scenarios were developed in as much detail as possible. They reflect existing and expected demand for mobility under the growth scenarios. It was not possible, however, to systematically review highways or light rail stations or HOV facilities in the networks to ensure that none were so underutilized as to be poor investments.

From a fiscal point of view, therefore, there are probably some transportation facilities in each network that are not justified. They are relatively few, however, and probably spread across the AUTO, VAN, and RAIL networks.

Section F: Feasibility of Scenarios

An effort was made to make each scenario be as reasonable as possible, regardless of how feasible it might seem from a practical point of view.

Some observers might feel that some of the scenarios are not realistic. For example, it would be easy for an opponent of growth to argue that the FAST scenario with its assumptions of 900,000 jobs and 600,000 households is unrealistic. An advocate of growth would probably feel the same about the SLOW scenario and its much lower totals. However, the objective of the Study is to provide better understanding of the forces that must be contended with. Prejudging the scenarios, regardless of how realistic or unrealistic they might appear to individual staff members or to advocates of a particular viewpoint, would not serve the purpose of the Study.

Section G: Succeeding Chapters

Chapters 2, 3, and 4 below describe the assumptions used in developing three alternative transportation facility networks that were used as the skeleton systems of the AUTO, VAN, and RAIL geographic patterns. Chapter 5 describes the assumptions used to assign numbers of jobs and housing units to small geographic areas, to accompany these transportation networks, so as to achieve the major combined geo-economic scenarios used for traffic and fiscal assessment (e.g. FAST/AUTO, FAST/RAIL, etc.) Chapter 6 outlines the elements of the Transit Incentives and Enhancements (TIE) package. Chapter 7 describes how the TRAVEL and FISCAL assessment models work, including some of their limitations. Chapters 8 and 9 outline how cost assumptions were made for new transportation networks and new water and sewer facilities. Chapter 10 outlines the results of the TRAVEL and FISCAL Model tests of a number of alternative geo-economic scenarios.

Chapter 2

The AUTO Scenario's Transportation Network

CHAPTER 2: THE AUTO SCENARIO'S TRANSPORTATION NETWORK

The AUTO scenario assumes continued reliance on private automobiles. The traffic improvements proposed in the AUTO scenario are those contained in the Master Plan of Highways.

Figure 2.1 is a map that shows all major portions of the Master Plan of Highways. The information from various area Master Plans was used to specify the ultimate, or build-out, number of travel lanes associated with the Master Plan of Highways. It should be noted, however, that for some roadways, particularly in down- County area, not all of the lanes included in the Master Plan of Highways were used in the analysis. An example is East-West Highway between Bethesda and Silver Spring. The construction of additional lanes in such an area is unlikely. The TRAVEL computer model uses this network, along with comparable highway networks of the other jurisdictions in the Washington Metropolitan Area.

Figure 2.2 shows unbuilt portions of the Master Plan of Highways, beyond those highway widenings and improvements that are part of the programmed network for the FY90 Annual Growth Policy. Appendix 1 gives a line-by-line listing of approximately 150 different additions that correspond to the unbuilt Master Plan of Highways as shown in Figure 2.2.

It is estimated that the buildout of the Master Plan of Highways will have approximately 50 percent more peak hour highway capacity than was available in 1987. As can be seen in Figure 2.2, this additional highway capacity is not uniformly distributed throughout the County, but tends to be greater in mid-County and up-County areas. When expected capacity changes are summarized by Planning or Policy Areas, most up-County areas have more than 100 percent increases in peak hour highway capacity over 1987.

The AUTO scenario also assumed some modest changes to existing transit services. Additional Metrobus and Ride-On routes were added and existing route frequencies were increased in order to generally respond to household and job growth, by Planning Areas, associated with the TREND scenario. In addition, the AUTO scenario assumed the extension of Metrorail to Glenmont and construction of a trolley line along the Georgetown Branch from Silver Spring to Bethesda. A planned transit extension beyond Shady Grove to Germantown/Clarksburg was not included in the AUTO scenario in order to highlight differences between the AUTO and the VAN and RAIL scenarios. Also, the AUTO scenario did not assume any improvements to park-and-ride access facilities to serve the transit routes.

Maryland Commuter Rail Service (MARC) service improvements that are already scheduled within the State's capital improvements program were also included in the AUTO scenario. The major improvement

FIGURE 2.1

Master Plan of Highways Network

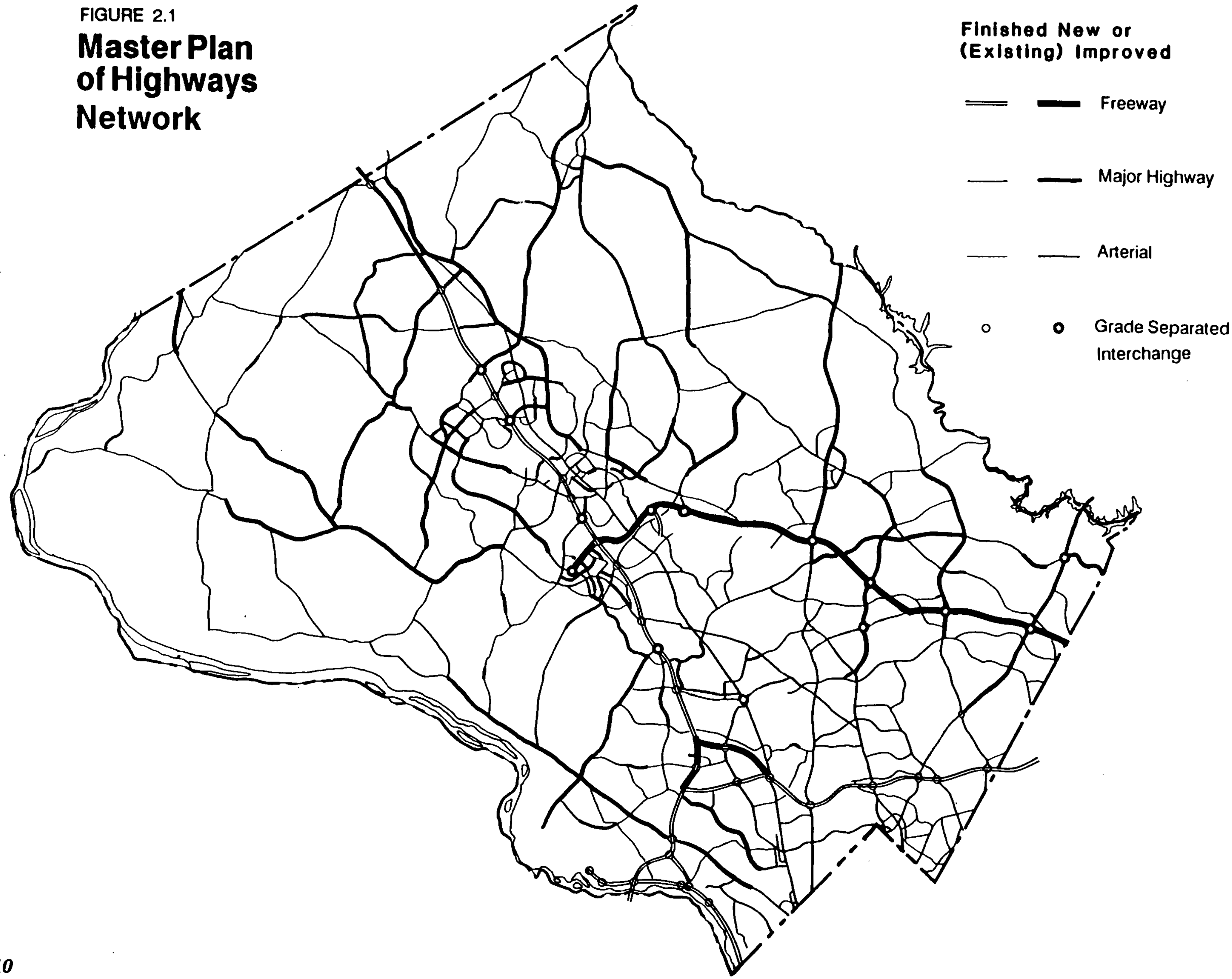
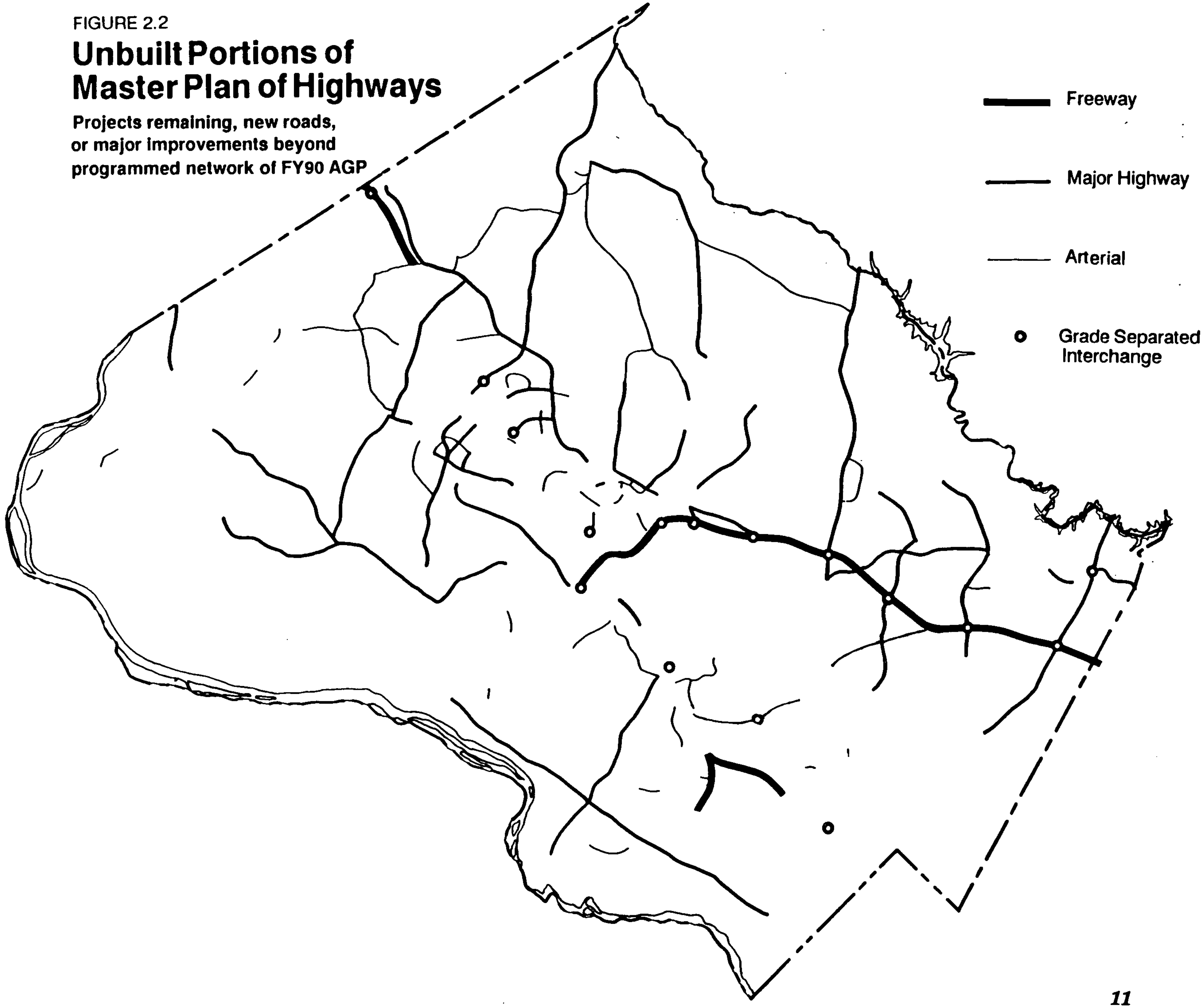


FIGURE 2.2

Unbuilt Portions of Master Plan of Highways

Projects remaining, new roads, or major improvements beyond programmed network of FY90 AGP



is a modest upgrading of service between Brunswick and Union Station.

No other major proposals for new transportation capacity were made in the AUTO scenario. While there is always potential for more effective management of traffic flow with traffic engineering techniques, such as improved signalization, such aspects are difficult to account for in the TRAVEL model. Hence, no specific allowance was made for improved traffic management.

In summary, the AUTO scenario is based upon the Master Plan of Highways which has evolved as a result of a long series of planning decisions over several decades. It should be noted that the above discussion is shorter than the similar discussions for the VAN and RAIL scenarios below. This is because, as indicated by the Master Plan of Highways, planning for the Master Plan of Highways is much better well known and understood.

Chapter 3

The VAN Scenario's Transportation Network

[redacted]

[redacted]

[redacted]

[redacted]

CHAPTER 3: THE VAN SCENARIO'S TRANSPORTATION NETWORK

Section A: The Value of HOV Facilities

HOV has come to mean a high occupancy car, presumably because people mostly see cars on HOV lanes. In fact, a large portion of the increased carrying capacity of HOV lanes comes from buses and vans. To emphasize this point and to simplify the name of a geographic scenario that could use a transportation network based on various combinations of buses and van pools and car pools, the name VAN was chosen for the geographic scenario. However, the term "HOV Network" is used herein to describe a set of separate rights-of-way to be used for either car and van pools or buses, or both.

Readers should be aware, however, that the TRAVEL simulation model's test of the HOV network was limited to its use by HOV cars. The test did not include modeling bus routes on HOV or any of the other possible HOV enhancements discussed later. Such tests will be conducted by staff subsequently. The HOV network chosen for this Study, when added to the present Master Plan of Highways and existing committed Metrorail system, constitutes the transportation skeleton of the VAN geographic scenario.

At its simplest level, however, the appeal of the HOV network is its ability to increase ridership per vehicle. It has been said that the problem with mass transportation in the suburbs is that there is no mass. Mass transportation works best when both jobs and housing are concentrated near stations. In suburban areas like Montgomery County there are relatively few concentrations of jobs and housing within walking distances of transit stations. The homes and the jobs, which are the origins and destinations of most trips, are dispersed.

Single occupant cars can get people between their homes and jobs, but the result is too many cars on the road. HOV offers the possibility of combining trips to reduce congestion, but still providing access to dispersed origins and destinations. In effect, HOV may theoretically offer mini-mass transit to reach mini-concentrations of jobs and housing. As the following sections indicate, the principle is simpler than its implementation.

Experience with HOV facilities is very new, and is based on only 300 directional miles of HOV lanes in eight states. A very limited number of places in the U.S.—Santa Clara County, California; Seattle, Washington; and Houston, Texas—are at the point of developing networks of HOV facilities, as opposed to isolated radial routes like the Shirley Highway and I-66. As a result of this relative lack of experience, the network proposed for the County is more subject to change, based on new information and evaluation, than is the transit network. Transit has a much richer history of proven experience on which to draw.

The fact that experience with HOV facilities is limited does not mean that they are unsuccessful. A survey of transportation planners and engineers in those metropolitan areas with HOV facilities found that all of them are planning expansions, totaling about 860 miles of HOV lanes. It also found that 80 percent of the planners and engineers said that public reaction had been favorable, and that 93 percent of the planners and engineers felt the HOV lanes were beneficial.

When asked "What would you do differently if you could plan your HOV facility again?" most said that more funds should have been spent on the facility and that the facility design should not have been compromised through lack of sufficient funds, such as overly narrow HOV lanes, lack of shoulders, and poor access and egress.

The Shirley Highway is a good example of the benefits of HOV facilities. In the COG Cordon Count in May of 1987, the AM peak hour count for the two HOV lanes was 13,460 people. The three conventional lanes carried only 9,821 people.

A few final points are useful as background. First, introduction of HOV lanes has known political problems, such as the case on the Santa Monica Freeway in Los Angeles in which an existing lane was converted to an HOV lane, thus reducing the amount of lanes conventional traffic could use. Strong protests resulted in the return of the lane for use by conventional traffic.

In sharp contrast, planners in Seattle used opinion surveys prior to and immediately after the development of HOV facilities to indicate to elected officials the depth of support for those facilities. It should be noted, however, that the Seattle HOV facilities were not created by taking lanes from conventional traffic. Elected officials were made aware through the survey that outspoken opposition to the facilities was representative of a relatively small percentage of their constituents. Over 70 percent of survey respondents strongly disagreed with the statement, "It's not fair to have special lanes set aside for buses, carpools, and vanpools."

It should also be noted that enforcement of HOV regulations has often been a problem when HOV lanes are not physically separate from regular traffic. Recently, however, enforcement has been considered as more of a cost issue. It is treated as such in this Study, with costs for enforcement included as part of the operating expenses for the HOV system. "HERO" lines, which allow the public to phone in to report HOV violators, have won public support and are apparently successful in Seattle and Virginia.

Table 3.1, Summary of HOV Experience, highlights key elements important to the success of HOV facilities. It seems to be particularly critical that the time savings of HOVs should be at least a mile a minute with a total overall trip time savings of at least 5-10 minutes.

It should be remembered that car pool riders often lose 5-10 minutes at the beginning of the work trip while pick-

TABLE 3.1 **Summary of HOV Experience**

TABLE A: LESSONS LEARNED FROM EXISTING HOV FACILITIES

Surveys of current operations suggest a growing consensus among planners and engineers about HOV project implementation. Current thinking based on this experience is that HOV mainline priority lanes are effective in increasing person throughput when:

- The non-HOV lanes are operating in a congested mode during at least the peak hours.
- The HOV facility expedites the flow of HOVs without adversely impacting the flow of mixed-flow traffic.
- The facility appears adequately utilized: when the HOV lane carries at least 800 to 1,000 vehicles in the peak hour.
- The time savings to HOVs exceeds 1 minute per mile with a total time savings of at least 5 to 10 minutes per trip.
- Development policy and operations management is closely coordinated from a regional and multi-agency perspective.
- The HOV lane is separated from mixed flow lanes by either an actual barrier or a buffer area.
- Enforcement is integrated into the design of the project.
- The HOV lane is implemented in conjunction with (and enhanced by) other strategies to increase vehicle occupancy such as park-and-ride lots, transit/carpool transfer centers, new bus services ("Freeway Flyer"), ramp treatments, carpool matching services, vanpool programs, etc.

Source:
Frank Cechini, "Making Sense Of It All: Operational Considerations In HOV Facility Implementation," Paper No. 880566 at the Transportation Research Board's Annual Meeting, January 22-26, 1989.

ing up members of the car pool. In addition, a typical work trip commute in the County is only 8.1 miles. For there to be adequate incentive to ride in an HOV vehicle, a Montgomery County commuter will have to be able to make most of that trip on HOV facilities. In particular, providing HOV facilities only on the Interstates and the Inter-County Connector (ICC) will probably not cover enough of the work trip of enough people to make HOV effective. This problem is illustrated in Figure 3.1.

Section B: The HOV Network

Figure 3.2 shows the extensive HOV network that was developed for the VAN scenario. The arrows indicate the direction of reversible facilities in the AM peak. With the exception of I-270 north of Shady Grove, HOV facilities on the Interstates and the ICC would operate in both directions.

HOV facilities on non-limited-access highways that run roughly north-south are southbound in the AM peak, and northbound in the PM peak. Typically, these will be reversible lanes. HOV facilities on non-limited-access highways that run roughly east-west generally operate in both directions and are not reversible.

It is generally accepted that it is easier to start with an HOV occupancy level of two persons per car (HOV-2), but such facilities offer far less increase in average automobile occupancy and corridor capacity than a required three persons per car (HOV-3). Three-person car pools, however, are much harder to form and maintain.

There is concern that if an HOV system starts with HOV-2, it may be difficult to go to HOV-3 when the lanes begin to approach capacity. Houston, Texas, recently raised its HOV level from two to three and is being watched carefully as to its results. The TRAVEL model test of the VAN scenario's HOV network has assumed HOV-3. It should also be noted that the HOV network would have opportunities for express bus services. The TRAVEL model analysis, however, assumed the same bus services for the VAN scenario's transportation network as in the AUTO scenario's transportation network, to test the potential mode shift to car pools independent of transit service enhancement.

Section C: HOV Treatments on Major Highways

The extensive HOV network used in VAN scenario required a wide variety of HOV treatments to reflect differences in highway type, and directional flows, as well as difficulty of adding new lanes or taking lanes away from conventional traffic.

There is a series of thirteen figures given in Appendix 2 that show the HOV treatments proposed for all the different links in the network, with one major exception that will be discussed later. The figures show the roads as they are, by type of road, and then by type of treatment. As they indicate, HOV treatments vary widely with different circumstances. The large number of ways

FIGURE 3.1 **Time saving with HOV Freeway only, versus time-savings with HOV on both Freeway and Arterials**

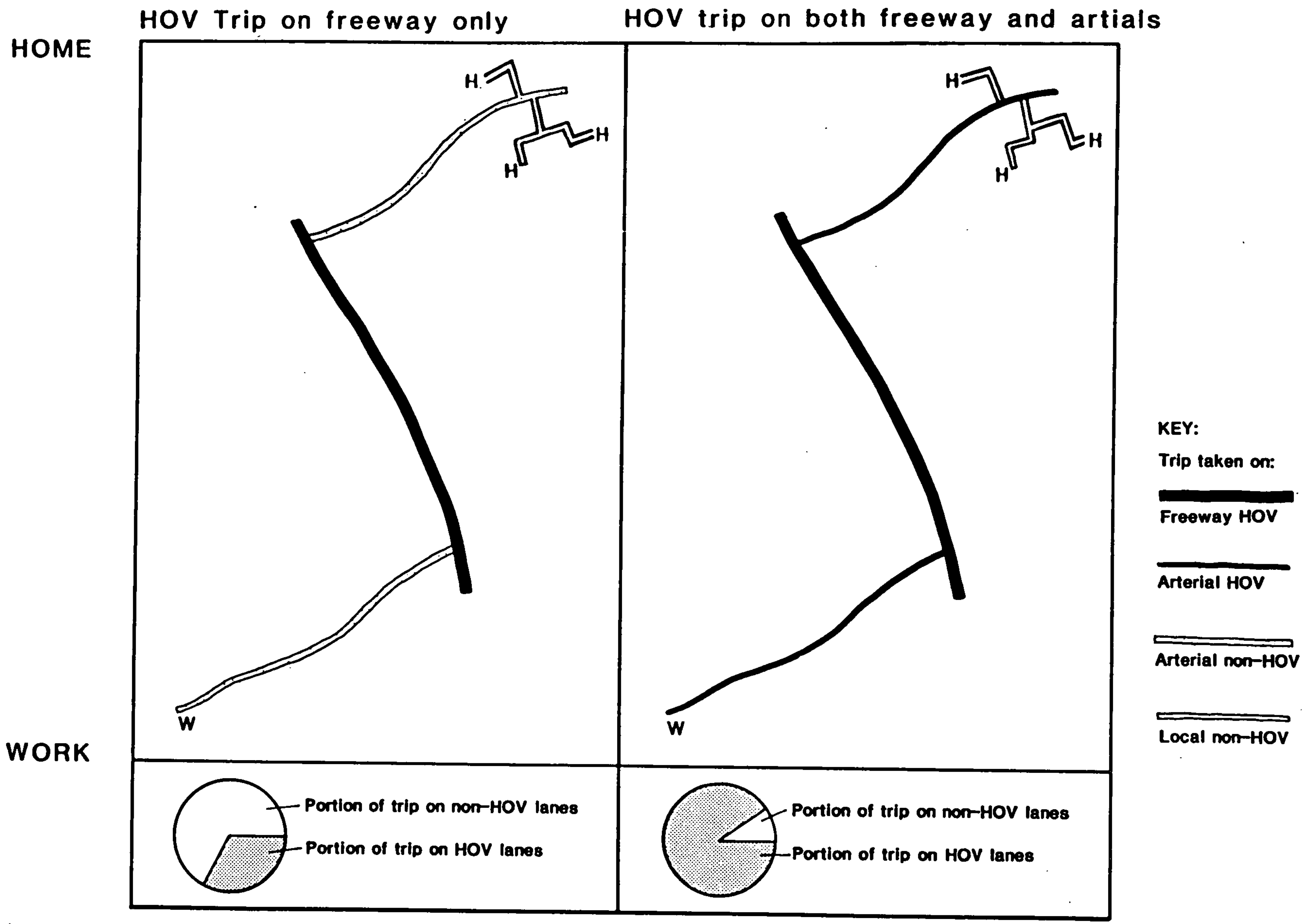
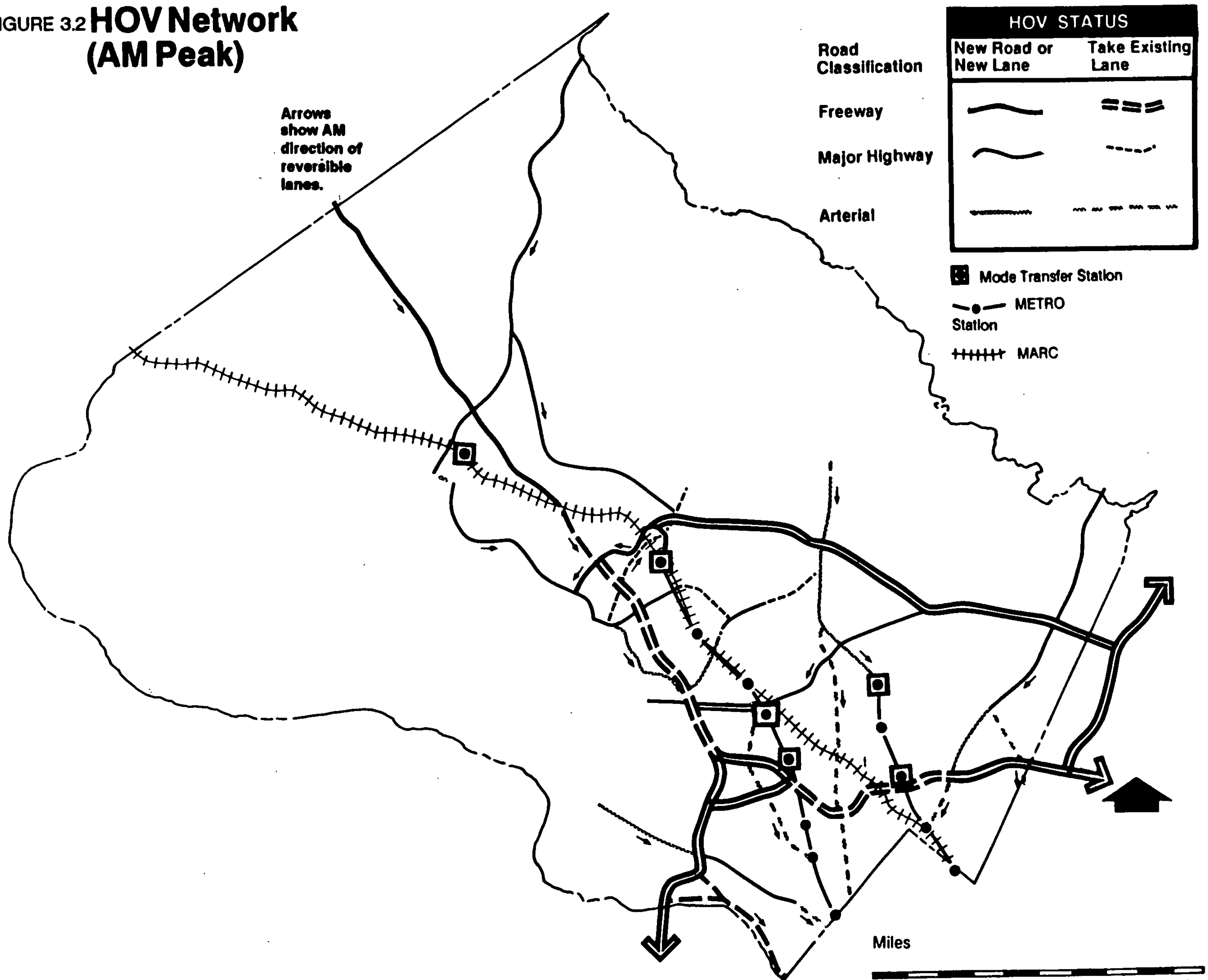


FIGURE 3.2 **HOV Network (AM Peak)**



to implement an HOV facility in any corridor made the VAN scenario harder to analyze and evaluate than the AUTO and RAIL scenarios.

Two major considerations shaped the choice of treatment. First is the problem of taking lanes away from existing traffic. Doing so, as mentioned earlier, tends to cause severe opposition immediately after the facility is opened when car pools are still being formed to respond to the opportunity to bypass traffic. During that period, commuters in the remaining conventional lanes see the HOV lanes being dramatically underutilized while their lanes are more congested.

To the extent possible, the proposed network minimizes lane taking and relies first on the use of remaining right-of-way, and then on removal of medians, before taking lanes from conventional traffic. In general, to diffuse the impact of a lane taking, HOV lanes should probably be opened well before a road reaches capacity. Doing so allows more time for formation of car pools. It also avoids a sudden step-up congestion directly associated with the introduction of the new HOV facility.

A second major consideration in designing the proposed network was the difference in directional traffic flow between the AM and PM peaks. Where there was a strong difference, reversible lanes were used. TRAVEL plots of traffic for the year 2020 for the AUTO network were used to see where differences in peak hour flows permitted reversible lanes. TRAVEL plots were also used as a rough guide to the number of HOV lanes required.

Due to time constraints, the network was not optimized by repeated runs to see which parts of the network were over- or under-utilized.

Section D: HOV Interchange Treatments

To accommodate both long and short trips on I-270, I-495, and the ICC, the VAN scenario assumes that those highways have not only separate HOV lanes but also ramp metering with HOV bypasses.

Ramp metering is a technique used to ensure that access to a limited access highway does not cause speeds to fall below about 35 mph, the speed of most efficient freeway operation. In ramp metering, cars are held at on-ramps by traffic lights and "metered" onto the highway to limit congestion and ensure that speeds do not fall below the desired level. While ramp metering has been adapted for HOV use, it is intended primarily to get the largest number of vehicles possible past any given point in an hour.

Ramp metering can be used to make a limited access highway an HOV facility simply by allowing HOV vehicles to bypass the LOV vehicles on an added lane. The HOV vehicles have faster access to the highway. It is an inexpensive HOV treatment, particularly in comparison to construction of physically separate lanes and interchanges. However, it should be noted that, unless ramp metering is accompanied by designated HOV lanes on the highways, its effect is limited, because once

on the freeway, HOVs and LOVs then travel at the same speed.

Ramp metering is not without problems, however. Unless multiple lanes are added to ramps to store vehicles waiting for access, traffic can back up onto arterials and into neighborhoods. On Route 35W in Minneapolis, multiple waiting lanes (up to four) have been used successfully to avoid this problem. Adequate right-of-way is necessary, but this problem is reduced to some extent by the fact that the lanes can be narrow because the cars waiting in them are stopped or moving at slow speeds. Ramp metering with a bypass lane for HOVs is shown in Figure 3.3 As indicated earlier, the TRAVEL model tests of the VAN scenarios assumed ramp metering on the HOV designated freeways in the VAN network.

Section E: HOV and Buses

As mentioned earlier, HOV facilities increase the attractiveness of using buses because the buses bypass congestion. This gives buses on HOV facilities two advantages over conventional bus service: they are faster and they are much more likely to keep to schedules. Schedule and travel time reliability is particularly important to transit riders.

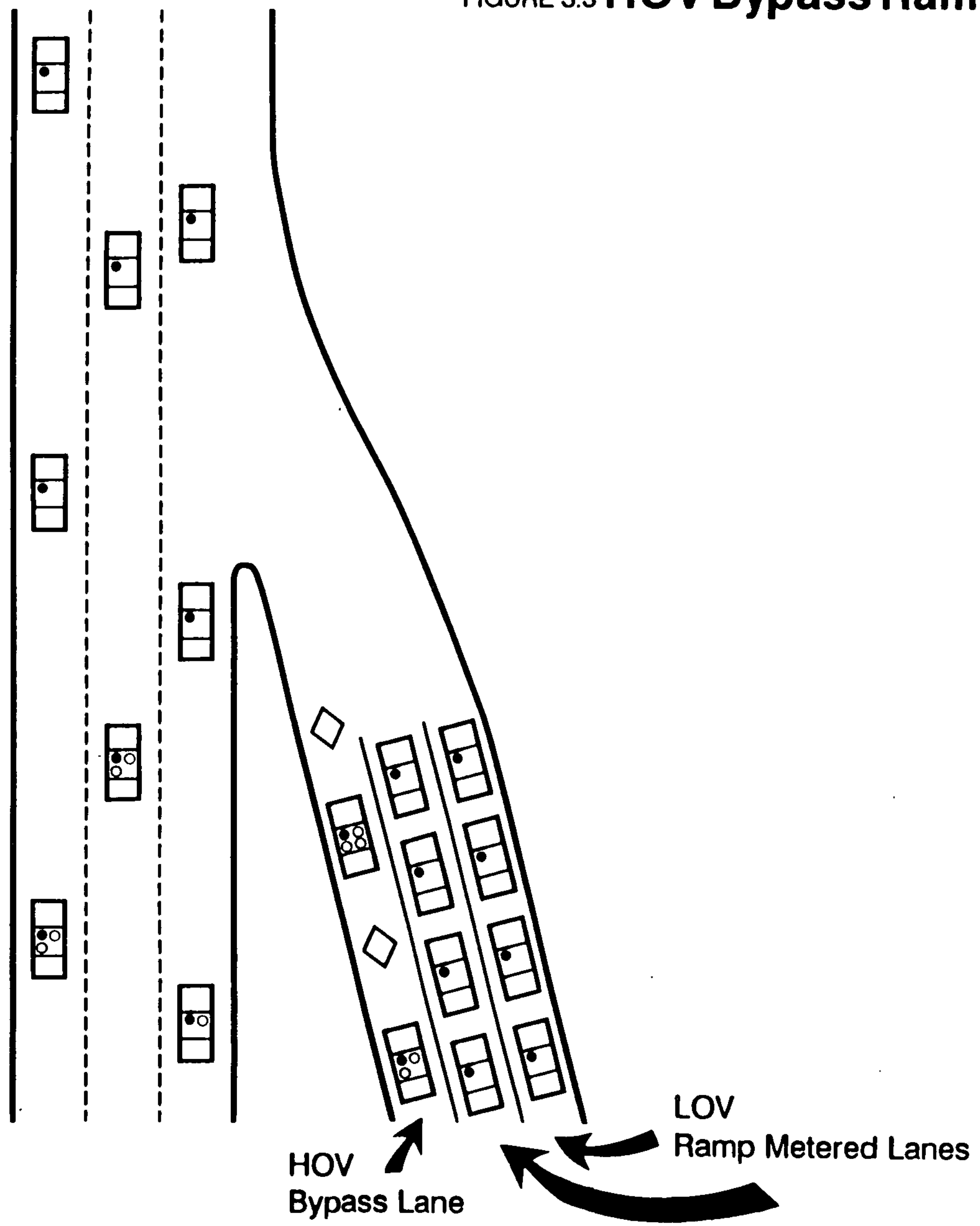
The Shirley Highway HOV facility is a good example of the attractiveness of buses on HOV lanes. Nearly one-third of the people who use the HOV facilities on the Shirley Highway in the AM rush hour ride in buses. It should also be noted that the bus riders were in just under 300 vehicles, as opposed to the almost 5,000 vehicles required for the remaining two-thirds of the people who rode in cars or vans. Those figures also give some idea of the potential increase in capacity that is possible from mode shift out of LOVS to buses on HOV lanes. (Information for 1987-88 provided to MCPD staff from MW Council of Governments.)

A study of the San Bernadino Express Busway in Los Angeles indicated that during its first five years of service, its ridership grew to 14,000, capturing about 25 percent of the trips in the corridor. The evaluation report states, "This mode share is comparable to other forms of transit. The principal reasons for choosing to ride a busway were time and cost saving, and freedom from traffic congestion." With HOV lanes, buses can provide service that is comparable in quality to good rail transit. The success of an exclusive busway system in Ottawa has proven this same point on a larger scale. In Ottawa, because of the busway system, there are fewer cars downtown than ten years ago, even though there are 10,000 more jobs downtown (information provided by Ian Stacy, Ottawa-Carleton Transport, at M-NCPPC Seminar, Sept. 16th, 1988).

It is also worth noting that the San Bernadino facility was initially developed as a busway, and later opened up to car pools. Bus running times did not change significantly with the introduction of car pools.

It should be emphasized that high bus-ridership figures on HOV lanes are probably only possible when there

FIGURE 3.3 **HOV Bypass Ramps**



are common origins and/or destinations and an express route between them. Stops are possible, and there are two on the San Bernadino Express Busway. They typically require, however, pedestrian bridges to bring passengers to stations adjacent to the HOV lanes in the center of the expressway. This is necessary to minimize delays for pick-ups.

In the case of the Shirley Highway, park-and-ride lots create common origins, and there are concentrated employment destinations in the Pentagon, Crystal City, and the District of Columbia. Many bus routes with local stops would not work on physically separated HOV facilities. It would be possible, however, to plan for concentrations of jobs and or housing near HOV facilities, just as is typically done for transit. It is also possible for buses to pick up passengers on local streets and then make an express trip on an HOV facility to an employment center. Buses on HOV facilities, as well as car pools, can also feed passengers to rail transit and local bus transit stations. Transit stations themselves are effectively concentrated.

Figure 3.2, the map of the HOV network, indicates mode transfer stations between the HOV network and the Metrorail and MARC Lines. Shady Grove, White Flint, Grosvenor, and Forest Glen would be the most important transfer points.

It should be emphasized again that the TRAVEL model so far has tested only the use of carpools on the HOV network. Further work will evaluate the congestion benefits of using buses also on these HOV network pathways.

The sections that follow attempt to outline some possible ways in which the HOV network could be improved for future TRAVEL model testing. Time did not permit their inclusion in the tests of the HOV network that were run for this report.

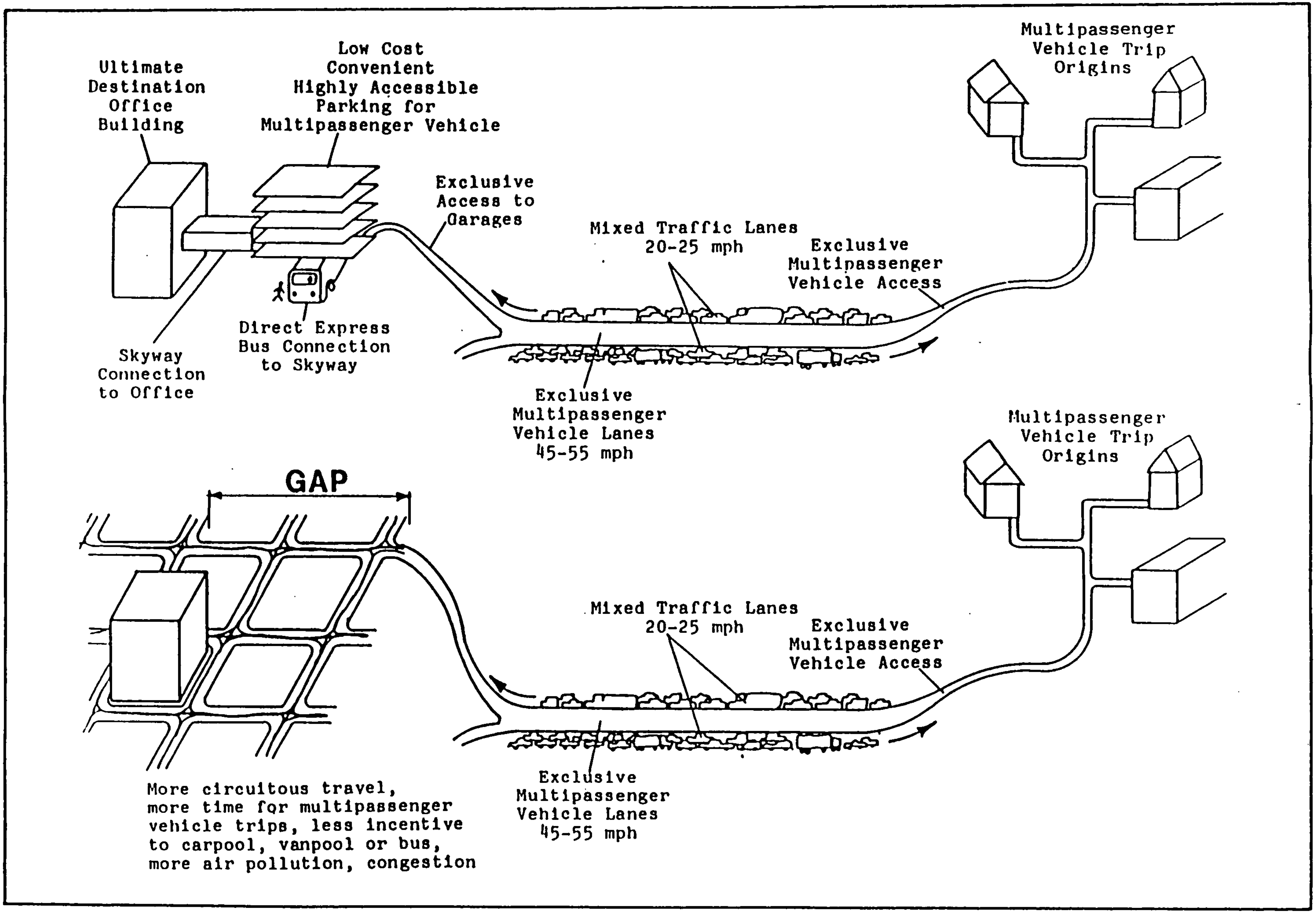
Section F: Possible Special HOV-Parking Linkages

Reserving the most accessible parking spaces for HOV vehicles and making these spaces free of cost, while charging high fees for SOV parking, can provide added incentives for carpooling and were included in the VAN network.

In Minneapolis, I-394, now under construction, has been planned with garages over its terminus in downtown Minneapolis. To increase the incentives for using the HOV facilities on I-394, the garages will have exclusive access from the HOV facility, with preferred spaces and lower charges for car pools. In addition, the first floors of the garages will act as inter-modal transfer stations for the downtown bus system. The garages will also provide access to the Minneapolis skywalk system. The system is illustrated in Figures 3.4 and 3.5.

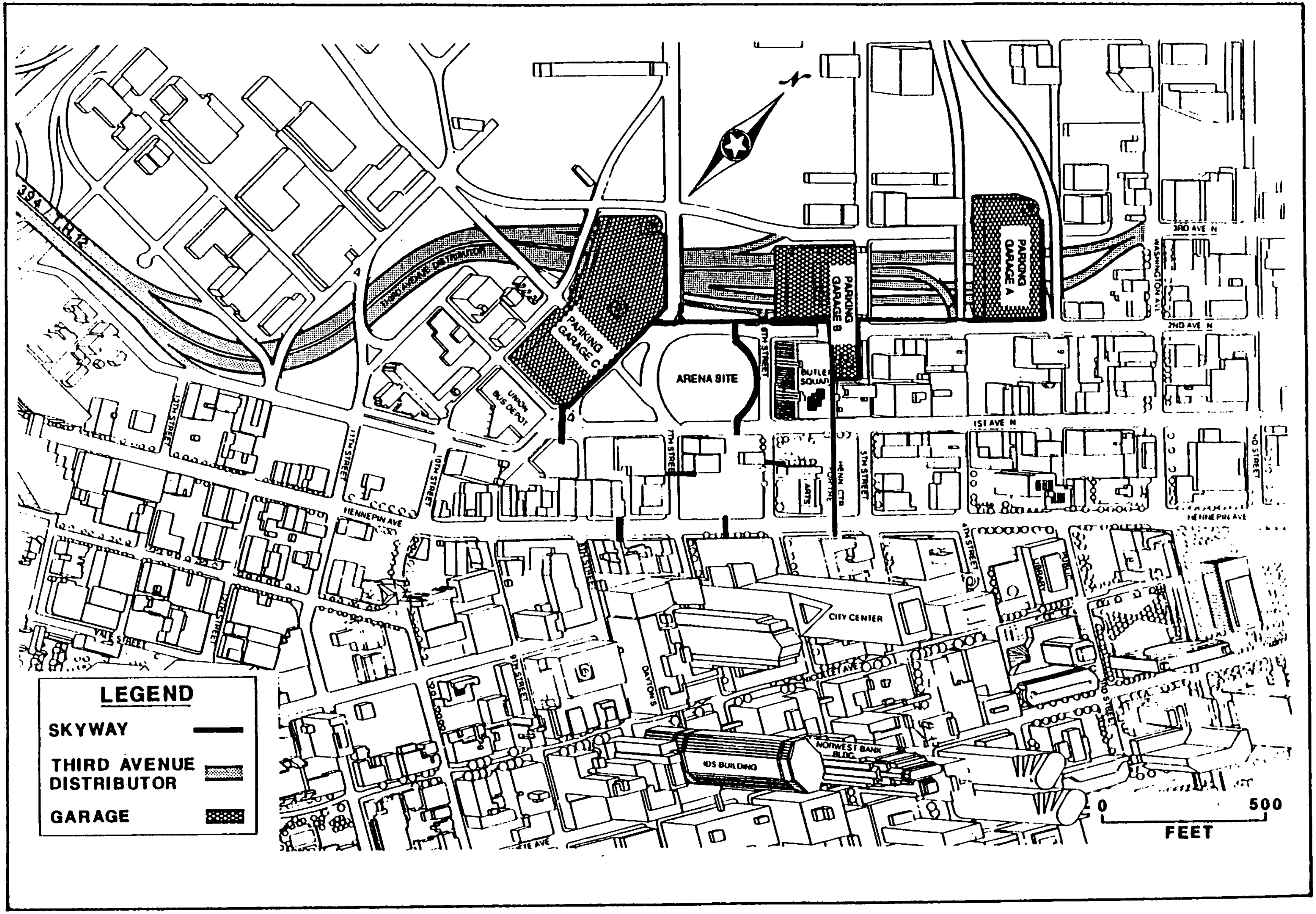
It would be possible to create garages, like those in Minneapolis, for office or industrial parks adjacent to major HOV facilities. An exclusive off ramp from the HOV

FIGURE 3.4 Minneapolis Portal-to-Portal HOV Concept



SOURCE: Draft Assessment of Need For Construction of Third Avenue Distributor Garage C, Minnesota Department of Transportation, Nov. 22, 1988

FIGURE 3.5 Minneapolis HOV Preference Garages and Bus Terminals



SOURCE: Draft Assessment of Need For Construction of Third Avenue Distributor Garage C, Minnesota Department of Transportation, Nov. 22, 1988

lanes would lead to a central parking structure, connected by sheltered sidewalks or skyways, to office blocks and/or light industrial buildings. The incentive to carpool would be strong because of the advantage of bypassing local traffic near the destination.

Also, as in Minneapolis, the HOV parking facility might be served by both local and express buses. The direct access for the express bus on and off the HOV lanes would mean that little time would be lost in stopping. Figures 3.6 and 3.7 show a schematic drawing of how such a garage might work if it were built over a freeway and included a bus stop and a pedestrian mall.

An alternative, less expensive means of achieving the same objective would be to replace the parking garage with direct access to existing parking. Since the HOV cars would frequently be entering from the rear or freeway sides of developments, this might be done using existing local access roads. The HOV vehicles would be traveling in the off-peak direction toward existing parking.

HOV garages could be transfer points to and from local bus service, possibly using a timed transfer system, with local buses arriving before and leaving after express buses. Timed transfers, also called systems, reduce transfer delay between relatively infrequent bus services.

In summary, there appear to be three ways to use the Minneapolis example to enhance the potential of the VAN network: direct access from HOV lanes to HOV parking garages in office and industrial parks, express bus service to those garages, and timed transfer between buses at the garages. Unfortunately, time did not permit the incorporation of these concepts into the HOV network or into the modeling of the VAN network by TRAVEL.

Section G: Possible New HOV-Accessible Nodes

As noted earlier the proposed HOV network, offers significant potential for mode transfer between buses on HOV facilities and Metro stations at Shady Grove, Grosvenor, White Flint and Forest Glen. The added accessibility of these locations would give them increased attractiveness as locations for jobs and/or housing.

Locations well served by HOV would have a similar attractiveness. The Davis Tract/Montgomery Mall area and Shady Grove are particularly well served by HOV facilities in the proposed network and would be appropriate for additional density. HOV might accommodate near-term clustered development in these areas, which could later be connected to Metro by new light rail stations to accommodate further clustered development.

The relationship between HOV facilities and land use is probably as important as the relationship between rail transit and land use. HOV facilities frequently encourage more long-distance commuting. The Shirley Highway HOV facility has helped stimulate residential construction as far south as Spotsylvania. It has been ob-

FIGURE 3.6 Section of Schematic for Bus Stop, HOV Parking Garage and Pedestrian Mall on Freeway

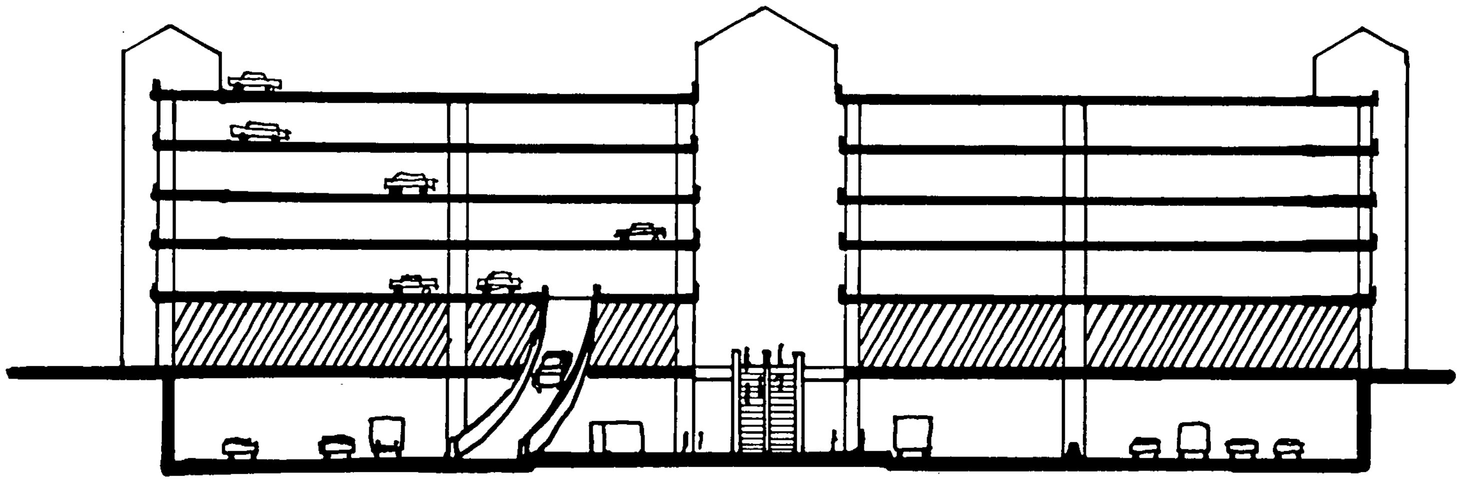
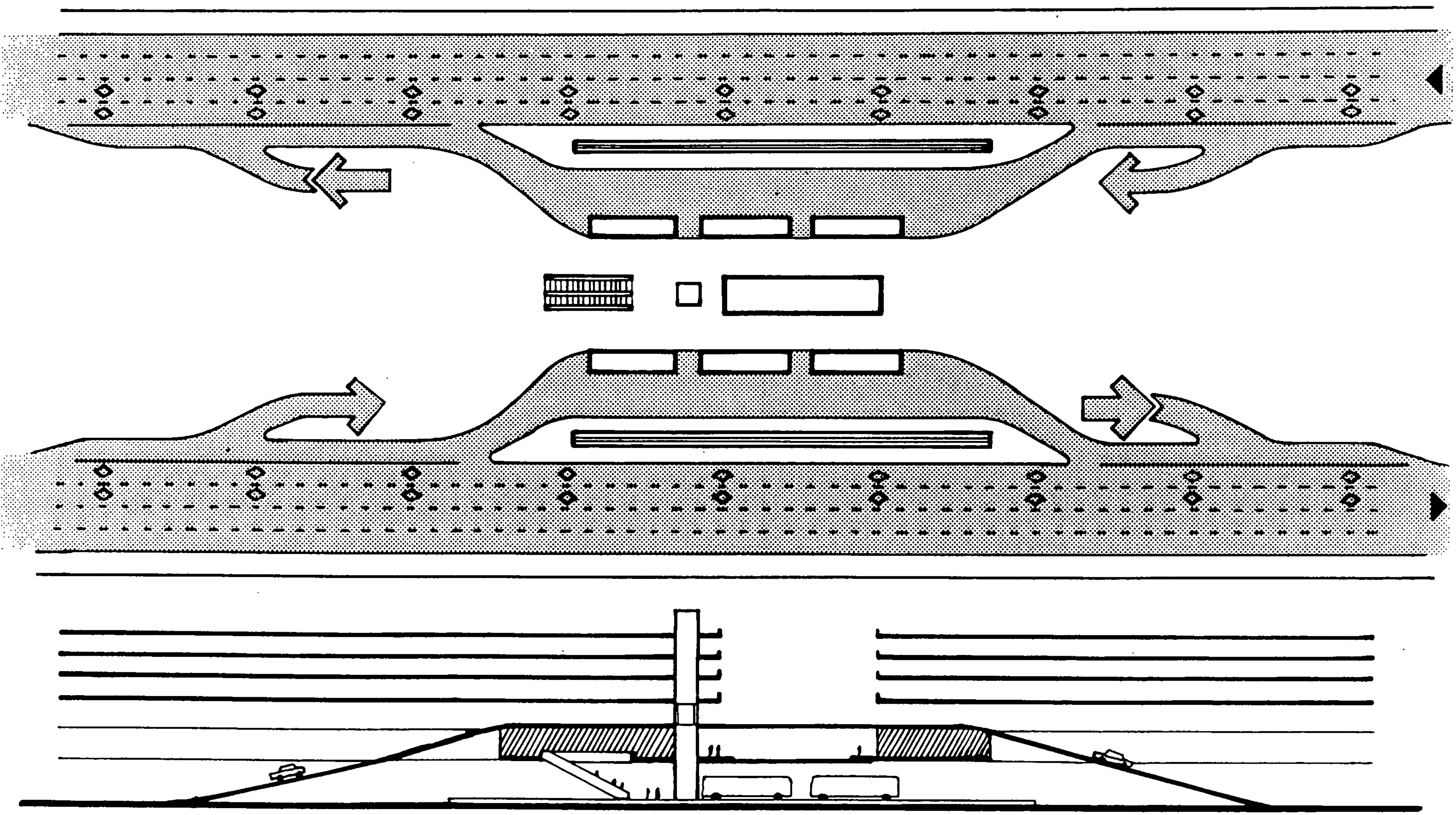


FIGURE 3.7 Schematic for Bus Stop, HOV Parking Garage and Pedestrian Mall on Freeway



served that some of the increased office development in Crystal City and the District of Columbia could be attributed to the Shirley Highway HOV lanes.

Section H: Possible HOV-Exempt Auto-Restricted Districts

Many of the County's business districts developed along roads leading to the District of Columbia. Bethesda and Silver Spring are the prime examples. Another is Wheaton, and the area of Rockville Pike between White Flint and Rockville suffers from the same problem. These areas are affected in two ways by having large amounts of through traffic. First, residents of adjacent areas face congestion in getting to neighborhood shopping, as well as making almost any trip. Second, the pedestrian environment suffers from having small safety islands or no safety islands, short walk lights, heavy traffic, and exhaust.

One way to address the impact of traffic in central business districts is auto restricted zones. A special license or sticker is required to enter the restricted area, or a significant fee is charged to enter, or some combination of these methods is used.

The principle of an auto restricted zone could possibly be applied in Montgomery County in a way that restricts vehicle trips but not person trips through CBDs. An HOV auto-restricted zone could be created in which HOV vehicles could pass through the zone unaffected during the morning rush hours, but lone occupant vehicles would have to have a special license or pay a fee. Local residents for whom the CBD represented local shopping would be issued special licenses free of charge. An auto-restricted zone with HOV bypass would probably require some form of automatic vehicle identification system, or fee collection system such as those discussed in the previous section. It would probably only operate during peak periods, so as not to restrict shopping traffic. Finally, it would also require a strong program of neighborhood protection to limit traffic cutting through adjacent neighborhoods to avoid the restricted zones. Many restrictions on cut-through traffic already exist, but would probably have to be strengthened.

There should be three benefits to this system. First, HOV vehicles including buses, as well as others willing to pay a fee, would face less local congestion and therefore would save time. Second, the impact of traffic on the business districts would be reduced. Finally, local residents would face less congestion in the business district adjacent to their homes.

Introduction of HOV auto-restricted zones would be difficult because they would generate opposition from the large numbers of drivers of single occupant vehicles. This resistance could be reduced, however, if the initial fees for special licenses to pass through the auto restricted zone were not high. Once the principle is established, the price could be raised to a level that caused an adequate reduction in congestion. An important side benefit of this system is that, in principle, it should not

only suppress LOV commuting, but also generate revenues that could be used to improve alternatives to the private car. Another important side effect would be that it would tend to reduce peak hour traffic and, therefore, congestion, both north and south of the auto-restricted zones.

Section I: Possible Toll Pricing for LOVs on Freeways

An alternative approach to making LOVs wait in storage ramps at freeway access points, while HOVs go forward, could be to charge LOVs for access. This could be done by using prepaid optical bar-code cards similar to the farecards used in the Metro system or by adopting automatic vehicle identification (AVI). AVI technology is now being used on a demonstration basis on the Coronado Bridge in San Diego and is under development for the Dulles Toll Road in Northern Virginia. Farecards would avoid concerns over protection of privacy that defenders of civil liberties raise in regard to AVI.

Tolls are charged for many parts of the interstate system, such as the Baltimore tunnel, the Massachusetts Turnpike, the JFK Memorial Highway, the New York Thruway, and a section of I-95 near Richmond. However, the federal government would have to grant legal authority to impose tolls on Interstate roads constructed with federal funding.

Tolls for LOVs could be set at a level to ensure nearly uncongested flow. If access were based on payment, vehicles driven by those unwilling to pay the toll would not be on the ramp, so there would be no backup problem. If farecards were used, they could be purchased at machines near freeway entrances. The price of access could be adjusted by time of day as well as by the number of vehicle occupants.

The problem with toll pricing for LOVs on freeways, however, is that it probably will include greater traffic congestion on arterial and local streets. Since local traffic congestion is a major problem already, this idea may not be useful unless it can be expanded in some ways, using modern computer technology, to the arterial streets as well. Toll pricing on arterials warrants evaluation, but was not assumed in the TRAVEL tests in this report.

Section J: Other HOV Considerations

One of the largest problems with HOV facilities is the effort of establishing and maintaining car pools. Assume, for example, that in a three-person car pool, each member has a 15 percent chance of not coming on any given day due to sickness, vacation, work related travel, or going in early or staying late to work. It follows that on any given day there is almost a 40 percent chance the car pool will not be complete.

An apparent response to this problem is informal carpooling, or instant carpooling, on the Shirley Highway. A line of riders forms at an Arthur Treacher's parking lot

on Old Keene Mill Road and at the Rolling Valley park-and-ride lot on Shiplett in the morning. Cars drive past the lines, announcing their destinations, and pick up riders to those destinations. Roughly 2500 people use the instant carpooling system each day, not including those picked up by cars at bus stops on roads leading to Shirley Highway.

A critical mass of commuters and drivers is needed to create the conditions for such systems to work. As Appendix 3 suggests, it may be possible to create such critical masses using improved information and communications technologies. Drivers wanting to use HOV facilities need to be able to know, as they start their cars, where someone in their neighborhood or at a convenient bus stop may be waiting for a ride to the same destination. A data-communications system could be devised to pair drivers with riders, much as taxi dispatchers pair cabs and customers, facilitating instant carpooling in communities. There has been little experience with modeling future travel on HOV systems. The techniques used were not sensitive to the potential for instant ridesharing or the assistance of improved communications technology.

Technology could also help resolve safety issues. It is comforting that there has not been a reported case of violence in the ten years the informal carpooling system has been working on Shirley Highway. Nonetheless, security will be a major issue. Emergency personal radio beacons now in use for offshore yachtsmen permit rescue boats to determine, with great accuracy, the locations of people lost overboard. The same device, adapted for use by both drivers and riders, might ensure immediate police response to the threat of violence from either driver or rider.

In summary, an extensive network of HOV facilities may not be the only way to provide greater incentive to carpool. It may also be possible to use communication technology to make formation of carpools easier.

Chapter 4

The RAIL Scenario's Transportation Network

CHAPTER 4: THE RAIL SCENARIO'S TRANSPORTATION NETWORK

Section A: The Focus on Light Rail

Light rail (e.g., trolleys) is a major element of the RAIL scenario because it offers high person-movement capacity at less cost than rapid rail (e.g., Metrorail). Further, it can be fitted into constrained rights-of-way by operating at grade on dedicated alignments or, where necessary, using short elevated or tunneled sections or operating in mixed traffic for short distances.

Capacity of Light Rail

If there are fully developed access and egress systems, light rail lines can readily carry up to 20,000 passengers per hour on a single track, contrasted with freeways, which usually carry little more than 2200 persons per hour per lane. While light rail's capacity is less than Metrorail's, costs are usually significantly lower. Metrorail systems must be grade separated from other traffic, while light rail lines can, if necessary, be routed through or across other traffic, although this compromises system speed and capacity. In many situations where Metrorail lines must be tunneled at great capital cost, often exceeding $100 million per mile, light rail lines can be developed to operate at grade at costs of $5 to $20 million per mile.

Because light rail cars are lighter than Metro vehicles, they can accelerate and decelerate more quickly, are quieter, and require smaller and cheaper structures when tight right-of-way conditions call for elevated track. Light rail vehicles are usually much quieter than diesel buses and are thus more compatible with residential neighborhoods, parks, and downtown pedestrian areas.

In many cities, light rail systems operate at grade for most of their routes and either go underground within dense city centers or run down the middle of pedestrian malls on streets formerly choked with automobile traffic. This is most successful when combined with policies that restrict downtown automobile use.

Light rail is more pedestrian-friendly than HOV because, when put down the middle of an arterial street, it can usually provide a safe haven for pedestrians trying to cross the street. HOV lanes usually have a more continuous stream of traffic and are thus better suited to expressway environments.

Access to Light Rail

Light rail stations can be built at very low cost compared to Metro stations, so more stations can be provided for the same budget. That makes it possible to link many more origins and destinations together within walking distance of rapid transit services. The more numerous stations also provide many more locations for the clustering of development at more modest densities than the

densities considered appropriate for Metro station development.

While Metro systems require elaborate stations, light rail vehicles often require nothing more than simple sidewalks for stations. This makes it possible to enhance opportunities for pedestrian access to the system at low cost. The importance of this is shown graphically in Figure 4.1. When trips do not originate or end near a transit stop, the difficulty of access to and from the station reduces ridership.

While closer stop spacing slows the average travel speed of vehicles, skip stop, express, or other service patterns can be readily combined with local services to tailor the light rail system to travel demand within a corridor. This means that pressures for high density development, often associated with Metro stations, are far less with light rail, which thus can be more easily retrofit into already built-up areas, which could better match residents' concerns about incompatible growth.

Section B: MARC and Metrorail

The focus of this chapter is on the development of new light rail networks. It should be noted first, however, that existing rail lines can be enhanced significantly by increased service levels and new stations to better serve existing or future town center development.

The RAIL network not only serves new development, but also can relieve congestion down-County. Figure 4.2 shows the network pattern for existing rail service expansion. The RAIL scenario seeks opportunities for closer Metro station spacing in order to provide better rail access.

In the RAIL scenarios, Metrorail would have three new stops between current stations. One additional stop would be near Montrose Road, where the Rockville Facility, MARC and Metrorail meet north of the existing White Flint station. Another would be at Woodmont, between the Twinbrook and Rockville Metro stations, and another at the Community College just north of Rockville. There would also be a modest extension of Metrorail from Shady Grove to Metropolitan Grove and Gaithersburg. The addition of stations not in the original plans is not a new idea for the Metro system: a new station along the Yellow Line in Alexandria is being considered.

These changes would enhance Metro's ability to serve intra-suburban travel demand in the I-270 corridor and provide new areas for clustered transit- and pedestrian-oriented development. Metrorail service frequency would be increased to reduce waits at stations, and local walk, bike, and feeder bus access would be enhanced.

An electrified MARC system would also take on a greater role in providing high-speed bi-directional peak period long distance commuter services to the I-270 Corridor, Silver Spring, and Union Station. In the RAIL pattern, headways to and from Brunswick would be upgraded to ten minutes.

FIGURE 4.1 **Transit Access Diagram**

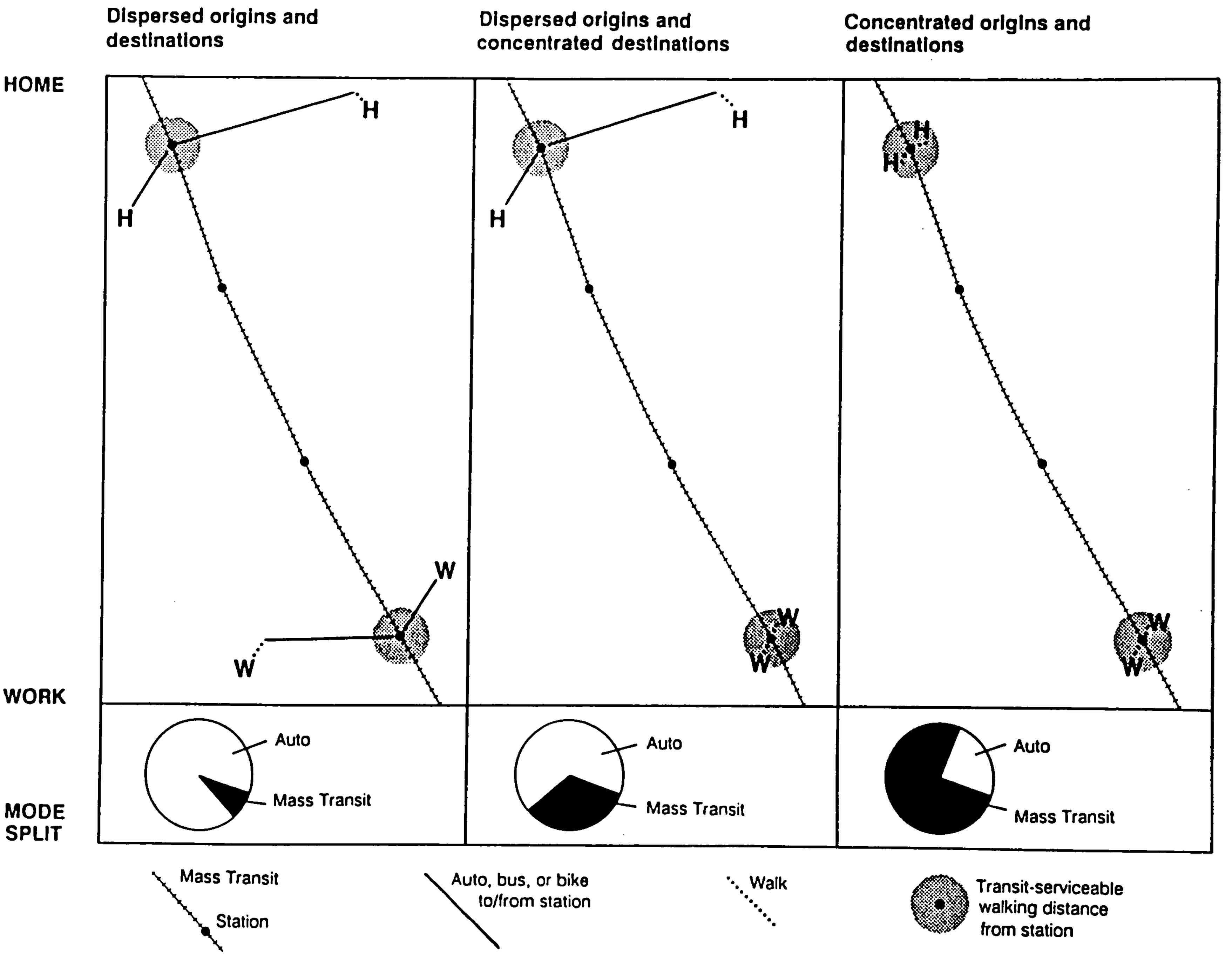
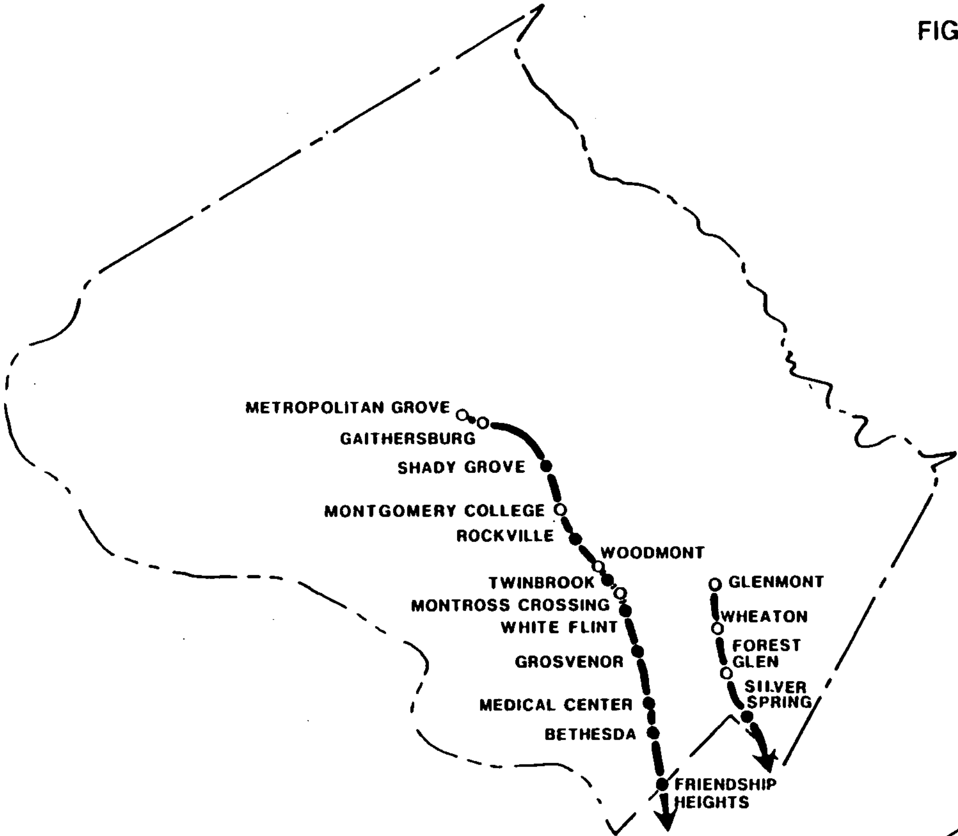
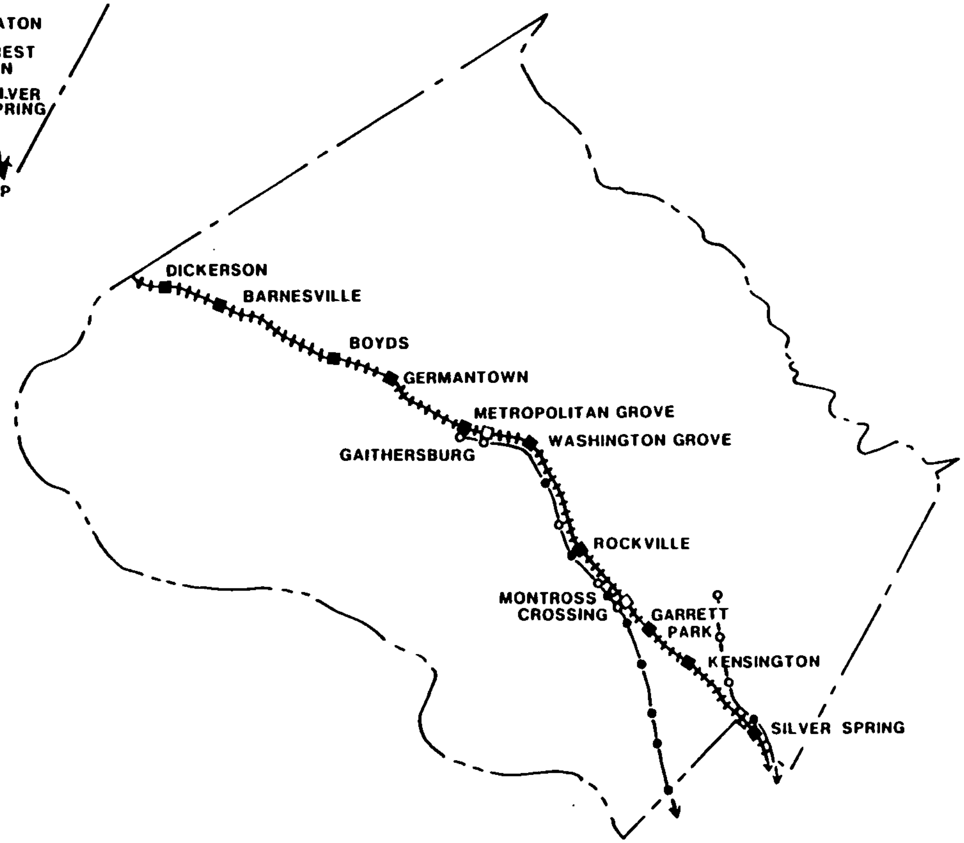


FIGURE 1.10 **RAIL Network: Metro Extension and MARC**



◄ 1. Metro Extensions and New Stations

2. MARC and New Stations ►



Section C: Light Rail Lines

The light rail network evaluated in the RAIL scenario would link existing development to Metro stations, would provide additional capacity for development, and would provide much greater network connectivity.

The light rail network would consist of five new major surface light rail lines, which would add to the Georgetown Branch line from Silver Spring to Bethesda assumed in the AUTO scenario. These five new lines would be:

1. Shady Grove to Fredericl
2. Shady Grove to Montrose Crossing
3. Montrose Crossing to Davis Tract to Tysons Corner to West Falls Church
4. Montrose Crossing to Wheaton to College Park to New Carrolton
5. Silver Spring to Columbia.

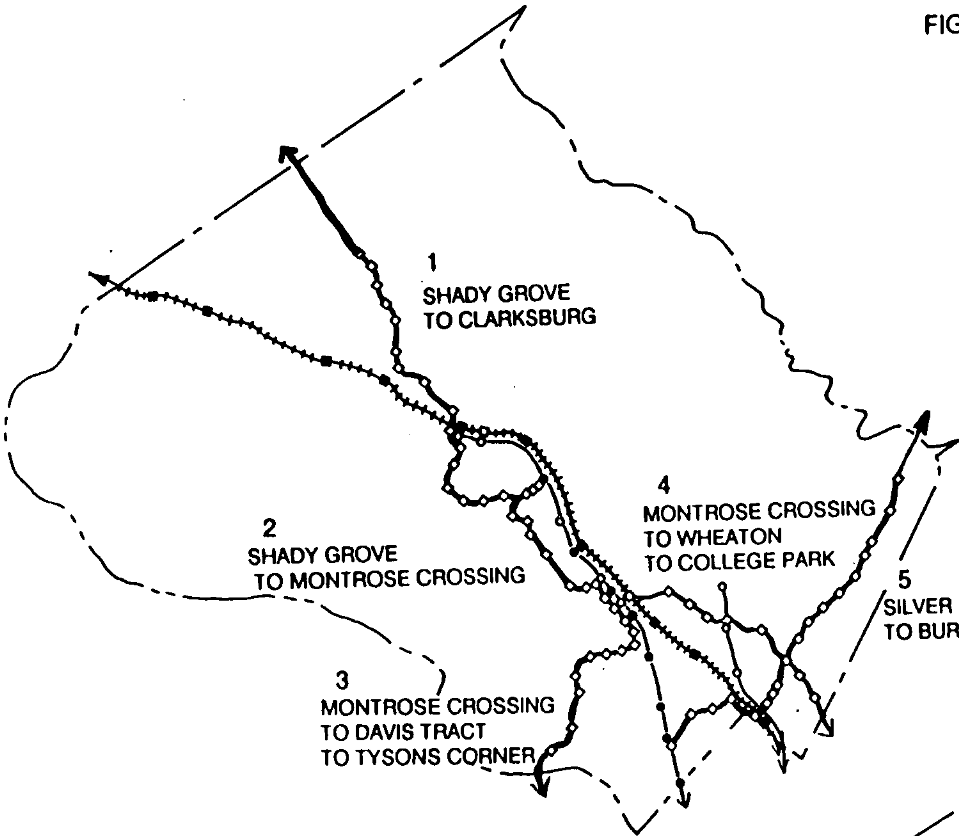
These lines are shown on Figure 4.3. The new lines would significantly expand radial service along the County's two major development corridors. They would also provide additional potential for growth within those corridors, and link many growth areas to Metrorail.

Finally, they would provide for circumferential movement along an arc from Tysons Corner, in Virginia, to Montgomery Mall to Rockville Pike to Wheaton to College Park and New Carrolton, in Maryland. It should be noted, however, that while movements along this arc would be circumferential in relationship to the region's core in the District of Columbia, they would be radial to suburban activity centers in the County such as North Bethesda, the Davis Tract, and Wheaton. These proposed lines would form part of a possible regional rail ring route, linking all the arms of the Metro system.

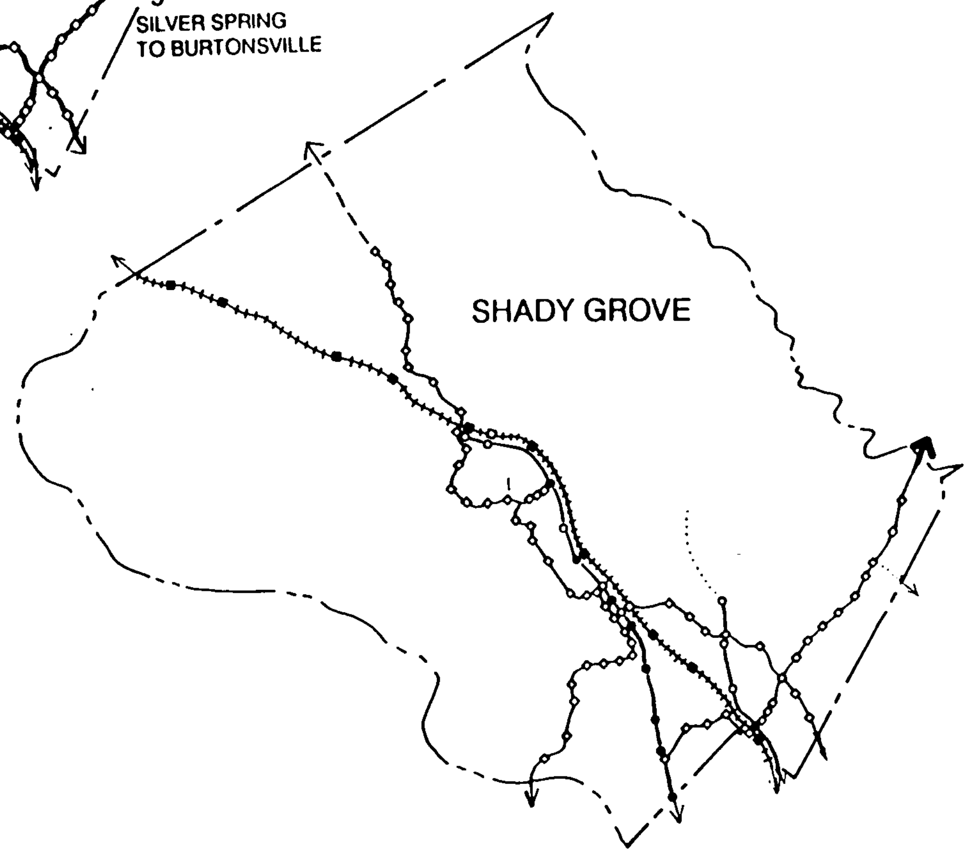
As an added note, it should be pointed out that, like London, Paris, Moscow, Tokyo, and other world-class cities, Washington needs a rail ring route to enhance regional rail network connectivity. The vast majority of employment growth in the Washington region is in the suburbs, yet the Metro system offers only very limited service between the major suburban growth centers. The logical next step beyond completing the region's 103-mile Metro system is construction of a rail ring route roughly parallel to the Beltway, connecting major growth areas to the Metro system and to each other.

Such a ring route could help alleviate some of the pressures on circumferential regional travel capacity that have led various interests to consider one or both of the proposed Western and Eastern Bypasses around Washington. Initial traffic forecasts done for that study show that both Beltway bridges will remain severely congested and that, even if the Bypasses were implemented, there would not be enough roadway capacity to serve the demand, even at today's level of congestion. Thus, it appears that some form of rail or HOV facility

FIGURE 4.2 **RAIL Network: Light RAIL and Priority Bus**



◀ 3. Light Rail Transit



4. Express bus lines ▶

should be given consideration to serve those circumferential corridors. In addition, the development of such a ring route, with complementary radial rail feeder lines where needed, could be expected to increase the utility of the region's substantial investment in the existing Metro system.

Section D: Bus Service in the RAIL Pattern

Feeder and local bus services were assumed to be significantly increased in the RAIL scenario in order to provide enhanced local travel and access to rapid transit, which inlcudes both light rail and rapid rail.

The assumed rail transit network required changes in the routing of buses so that so that they would feed passengers to the new transit stops.

On non-limited-access facilities, it is possible to create bus priority systems. This can be done by installing bus-only queue jumper lights at intersections. Doing so will also require stripes to mark a lane for buses only, or creation of additional right hand lanes at intersections for buses.

Roads on which bus priority would operate are indicated on Figure 4.4. It is worth emphasizing that giving buses priority through queue jumper lights creates a strong incentive to use buses. A bus that operates in conventional traffic, because of the need to stop and discharge passengers, will always be considerably slower than the private automobile. Queue jumpers begin to change that relationship, particularly during rush hours when traffic is heavy.

Timed transfer services to improve the quality of transit connections are considered as part of the RAIL scenario but these cannot readily be accounted for in the TRAVEL model.

Section E: Park-and-Ride and Bicycle Access

Numerous small automobile park-and-ride lots and improved bicycle access facilities would be located along the expanded transit system to provide access to the system for people living beyond walking distance of transit services.

Under any RAIL scenario, hundreds of thousands of Montgomery County residents would continue to enjoy living in low density single-family homes beyond easy walking distance of current or future Metro or light rail stations. These homes would continue to provide a major and vital portion of the County's housing supply.

While the expanded feeder bus services would provide access for some of these residents to the rapid transit system, many would continue to rely on automobiles to access rapid transit, using many new small park-and-ride lots at stations. The TRAVEL model analysis of the RAIL scenario assumes that these park-and-ride lots would charge users $3 a day, reflecting the real costs of building and maintaining such facilities.

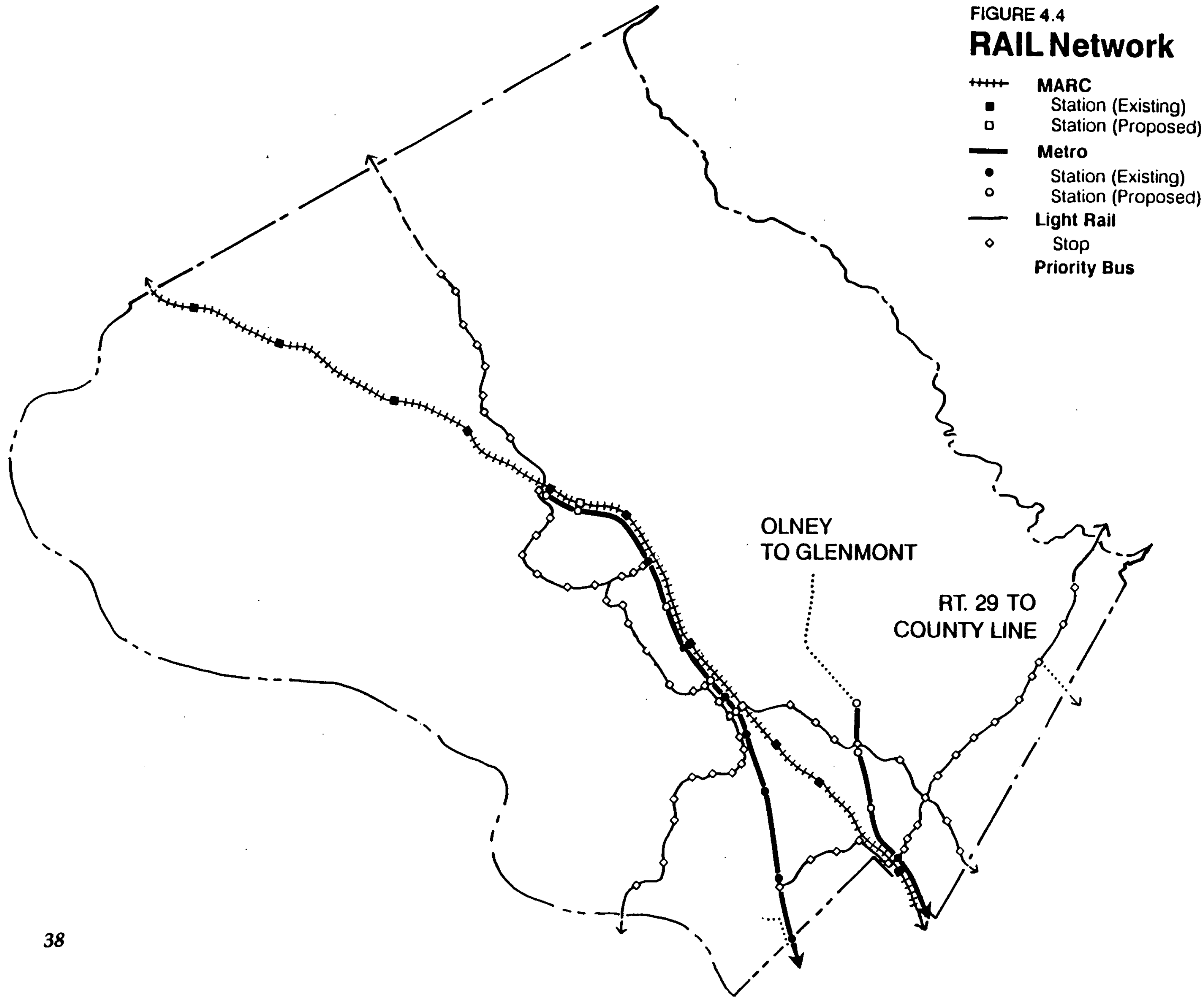


FIGURE 4.4
RAIL Network
MARC
Station (Existing)
Station (Proposed)
Metro
Station (Existing)
Station (Proposed)
Light Rail
Stop
Priority Bus
OLNEY
TO GLENMONT
RT. 29 TO
COUNTY LINE

The RAIL scenario also assumes that high quality bicycle paths and secure bicycle parking systems are provided to make it safe, easy, and comfortable to ride a bicycle to Metro, light rail, and commuter rail stations from within a several mile radius. Such paths and storage systems are very common in Japanese and European suburbs, where bicycles typically account for one-fourth to one-half of suburban express transit access trips. Similar paths and storage systems are being developed as well in some American communities. These improved bicycle access systems can also make it easy to get from the stations to nearby suburban employment centers not otherwise well served by public transportation. While included in the RAIL scenario, these improved bicycle access systems have not been explicitly accounted for in the TRAVEL model mode choice estimates.

Section F: Clustering Development Around Nodes

For the RAIL scenario to be most cost-effective, zoning capacity for new job and housing growth should mostly be clustered near existing or planned transit stations, with density decreasing with distance from stations. This idea is consistent with the "wedges and corridors" concept in the General Plan adopted by the County twenty years ago. The question for the future is how dense and concentrated these growth clusters, or activity nodes, should be.

In many cases, the pattern used in the RAIL scenario asumes a number of growth nodes around rail transit stops that would require changes in current zoning. There would not only be increases in zoning capacity near rail stops, but also some decreases in capacity elsewhere to reduce the tendency towards suburban sprawl. These changes would have to involve careful consideration of equity issues, as well as careful consideration of the impact of zoning changes on adjoining development. This study does not address the issue of how those zoning changes would be implemented.

Regardless of how they are achieved, changes in zoning and land use patterns that carry foward the original clustering concepts of the General Plan, *On Wedges and Corridors,* would clearly be called for to make the RAIL scenario most cost-effective. The potential use of light rail would be significantly less if development is not clustered in pedestrian and transit oriented growth nodes around transit stops.

Section G: Final Points

For the RAIL scenario to be acceptable, the County's efforts to protect residential neighborhoods adjoining clustered growth areas from through traffic intrusion should be intensified.

The same is equally true of the VAN scenario.

Also, it should be noted that rail and bus transit will become easier to use and more reliable as improved pas-

senger information systems, real-time passenger demand and vehicle monitoring systems, and other electronic productivity improvements become more available.

Improved passenger information systems can reduce the uncertainty felt by people waiting for transit vehicles and can allow people to better schedule their arrivals at bus stops to minimize wait times. Improved vehicle and passenger demand monitoring can reduce the bunching of buses, improving schedule adherence and transit system reliability. Better communications and vehicle control technologies can make timed transfer systems for buses operating in low-density settings work more effectively, reducing the problems of missed connections and long transfer wait times. Magnetic stored fare instruments and improved fare collection systems can reduce bus and light rail boarding times, increasing transit efficiency. Other technology advances can be anticipated to make transit services of the future more reliable and pleasant to use.

Chapter 5

Jobs and Housing in the Geographic Scenarios

CHAPTER 5: JOBS AND HOUSING IN THE GEOGRAPHIC SCENARIOS

Section A: AUTO SCENARIO

In order to test different transportation networks, the TRAVEL traffic simulation model must know the location of housing units and jobs within traffic zones. For the AUTO scenario, it was assumed that future development would reflect existing zoning. Accordingly, the growth in jobs and housing was allocated to traffic zones in proportion to remaining zoning capacity.

First, the maximum number of jobs and households permitted under existing zoning was calculated for each traffic zone. From that maximum, the number of housing units and jobs currently estimated for the year 1990 was subtracted. The result was the remaining zoning capacity by traffic zone. New growth in jobs and housing was then allocated to traffic zones in proportion to that remaining capacity. If a given traffic zone had a certain percentage of the remaining zoning capacity for housing, it would get the same percentage of the new housing units for each growth scenario. In effect, this method assumes an even distribution of new growth over the county, and tends to ignore possible cluster pressures that the private market might create for specific sub-areas.

Fitting in the numbers of jobs and houses for some of the scenarios necessarily meant exceeding the remaining capacity in the zoning envelope. For the AUTO scenario, it seemed appropriate to exceed that capacity systematically in proportion to current zoning.

Section B: VAN SCENARIO

For the VAN scenario, growth in housing was located in proportion to remaining residential zoning capacity, and growth in jobs was located as it was in the RAIL scenario (i.e. clustered at nodes along rail lines). This reflects the assumption that HOV facilities can serve to connect single-family densities for housing with much higher densities for jobs.

The discussion of the development of the HOV network in the earlier section reviews several ways in which the network might influence development. By the time those concepts had evolved, there was not time to develop a land use pattern that reflected them. In addition, there was not time to create within TRAVEL the coding of a network that reflected them.

In the face of this time shortage, it was decided that the *housing* distribution for the VAN scenario would be the same one used for the AUTO scenario. This decision seems to be consistent with one of the major benefits of the VAN scenario. Specifically, with HOV, it does not seem as necessary to change residential zoning to concentrate new housing near transit stations.

For the allocation of *jobs* in the VAN scenario, it was decided to use the RAIL scenario allocation. Figure 5.1 shows the HOV network overlaid on growth nodes from the RAIL scenario. As it indicates, the growth nodes from the RAIL scenario, for the most part, would

be well served by the assumed HOV network from the VAN scenario.

Section C: RAIL NETWORK

For the RAIL scenario, most growth, for both jobs and housing, was clustered around transit stops. The allocation of jobs and housing to specific traffic zones for the RAIL scenario was based on the transit network. New and existing transit stops were designated as growth nodes. Specifically, the area within 2000 feet of each transit stop was considered within walking distance of transit and appropriate for growth, as shown in Figure 5.2.

Upper limits for jobs and housing were then developed for each growth node. Urban design criteria were applied to see how many additional jobs and households the node could accept before the visual and scale character of the area became unacceptable.

This was a highly judgmental exercise. It was deliberately skewed towards the high end of the density spectrum, for the purpose of allowing the TRAVEL model to test the maximum mode shift to transit that could be achieved by clustering jobs and housing around transit stations. Existing development within and adjacent to the node was taken into account. An example of the work sheets used for this process is provided in Figure 5.3. For transit stops that were not yet developed, a simple concept of a node, as shown in Figure 5.4 was used to estimate new job and housing capacity.

The total number of jobs and housing units that could be accommodated by the locations selected under these assumptions was higher than the numbers needed for the FAST scenario. This permitted some freedom of choice in location to tailor the distribution of densities to the stations selected for the combined FAST/RAIL scenario.

In addition, it was assumed that there would be an additional 15 percent growth in the jobs and housing in zones outside the 2000 foot walking distance of transit stations, to allow for growth of existing businesses and some residential infill and creation of accessory apartments. As far as possible, efforts were made to avoid taking green space or placing incompatible development next to single-family neighborhoods.

Figures 5.5 through 5.8 give some feel for the location of assumed development in the County for the four different economic scenarios when combined with the RAIL geographic scenario. The first two figures, 5.5 and 5.6, show jobs and housing by policy area for the FAST and SLOW scenarios. The second two show jobs and housing by policy area for the JOBS and HOUSING scenarios. Figure 5.10 (page 54) shows the location of the policy areas represented by the vertical bars in Figures 5.5 through 5.8

In searching for locations for potential clustered development within the existing developed areas of the County, a number of concepts were explored. Some of these might be politically or economically unacceptable

FIGURE 5.1

Location of New Jobs in Relation to HOV Network

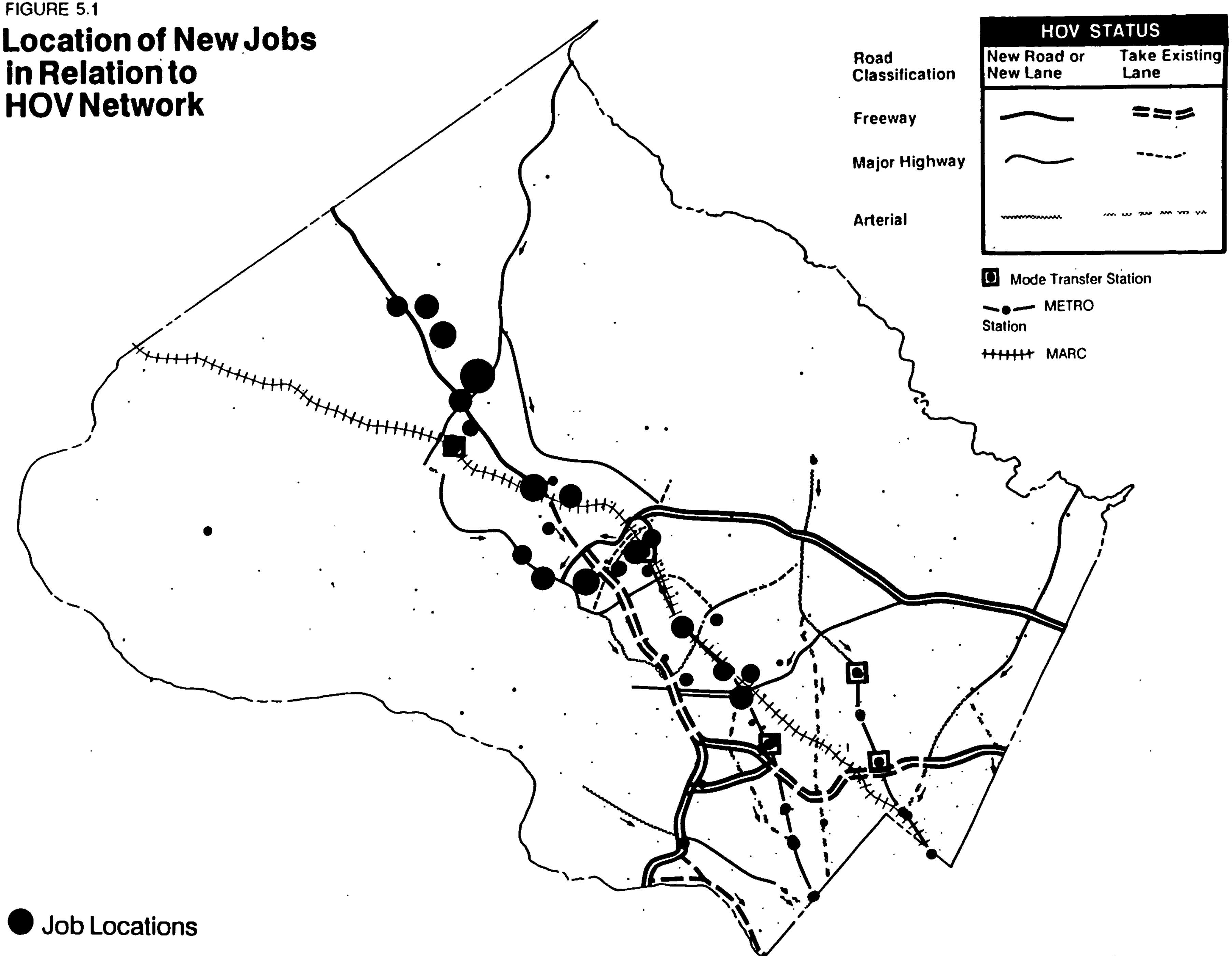


FIGURE 5.2 **Diagram of Density versus Distance to Transit Stop**

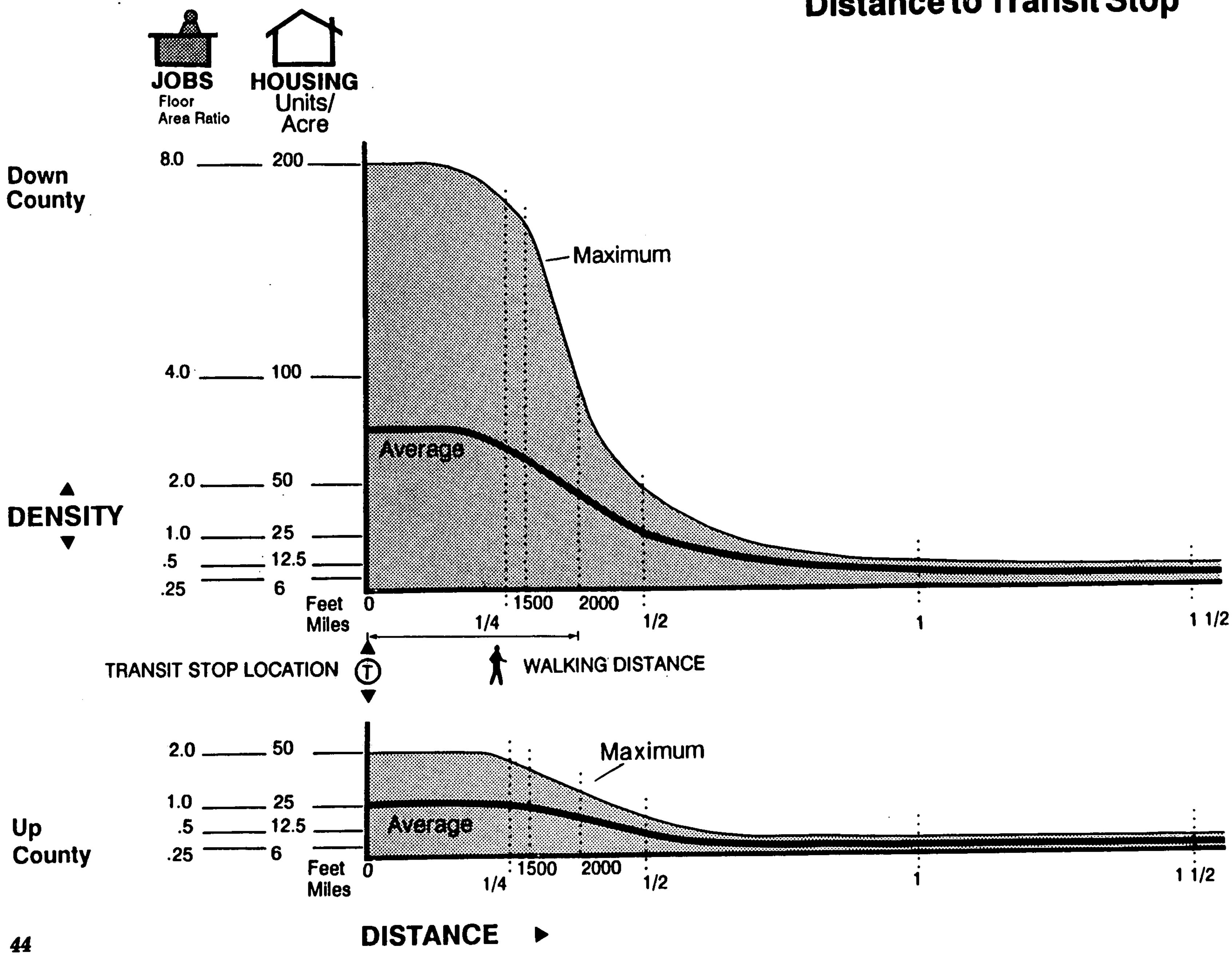


FIGURE 5.3 Down-County Node

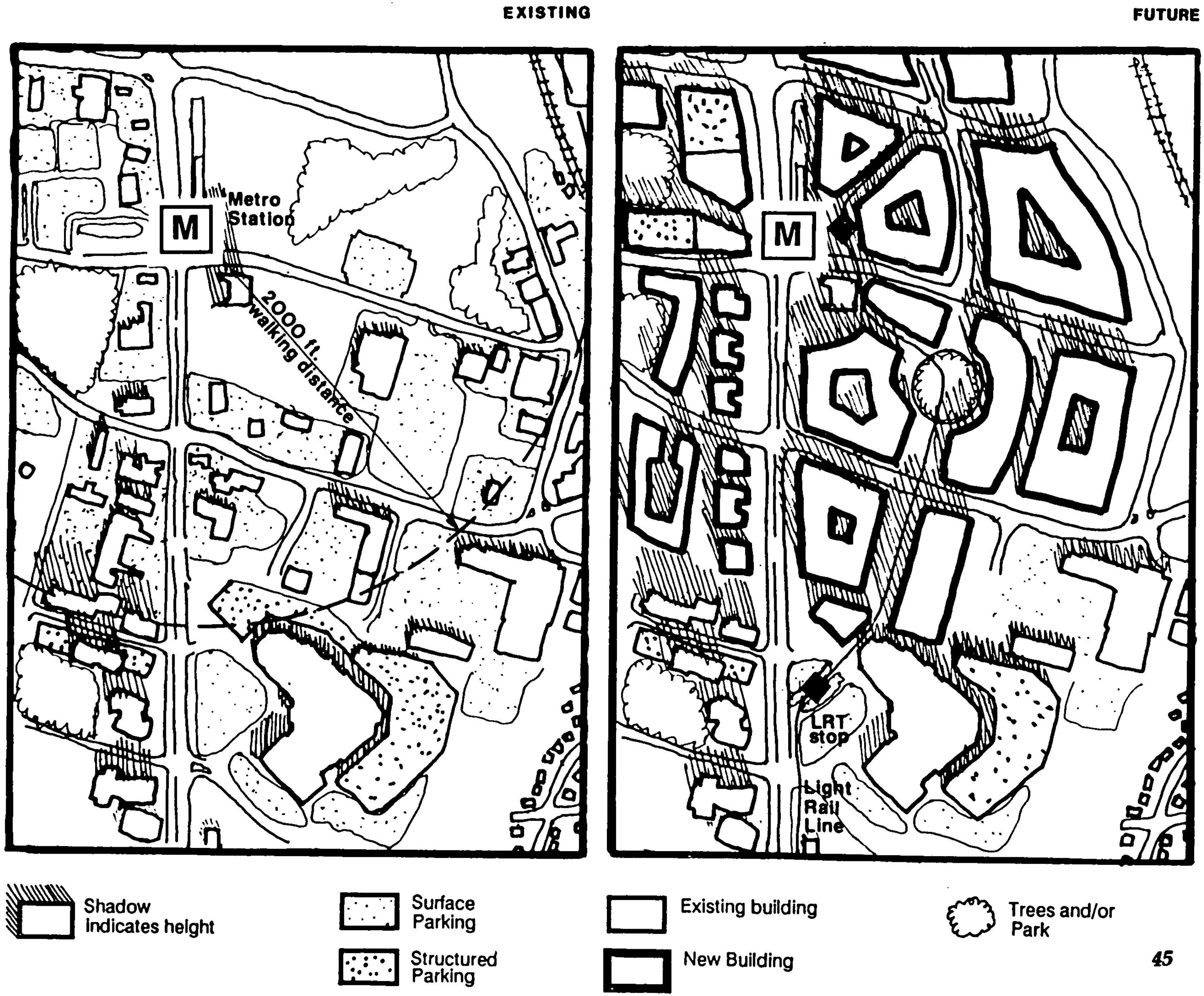
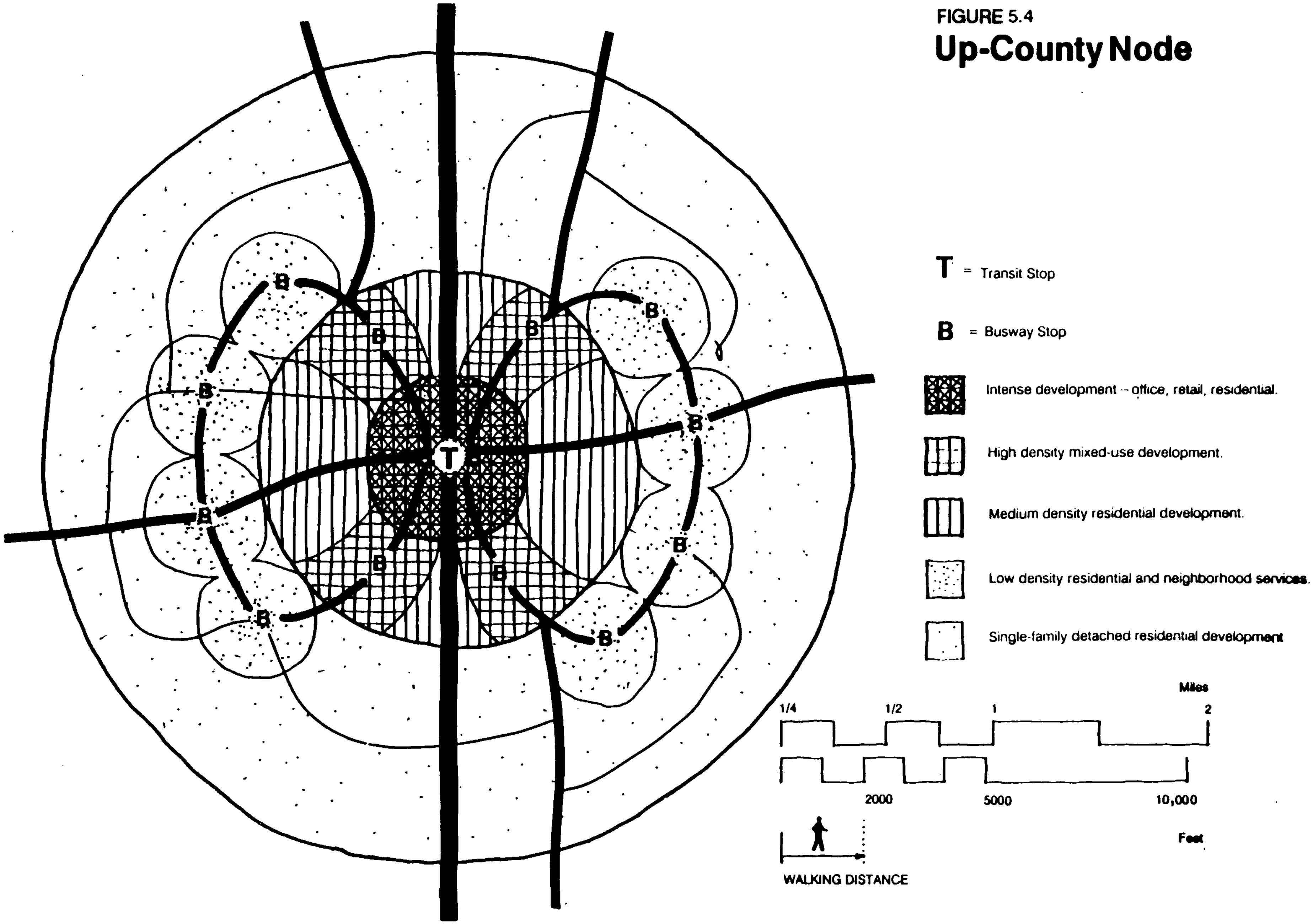


FIGURE 5.4
Up-County Node



but appeared to merit consideration in a long-range strategic planning study.

First consideration was given to locating possible undeveloped and redeveloped sites. This was followed by the selection of certain parcels for assignment of higher densities for testing purposes. In some locations, shopping center parking lots were assumed to become high density housing and town or village centers.

In a few locations, it was assumed that golf courses or portions of golf courses might be developed. In other locations, air rights developments over expressway interchanges were identified as potential locations for clustered mixed use town or village centers within the existing web of lower-density development.

In the RAIL South scenario, it was assumed that mid- and high-rise housing might replace some houses on the blocks immediately abutting high traffic volume arterial streets in some areas near Metro or light rail stations. Such housing could help in increasing the housing supply near employment centers.

This RAIL South scenario concentrated additional new housing capacity and transit services in the southern part of the County to maximize the use of existing road, transit, sewer, and school infrastructure. By focusing new infrastructure investments and infill development in this area, and locating housing closer to jobs, work trips would have much higher transit, walk, and bicycle mode shares for the same levels of infrastructure investment. Also energy use and air and water pollution would be reduced.

On the other hand, this RAIL South scenario would have more impact in terms of compatibility with existing developed areas. Such a strategy undoubtedly would meet with strong resistance from existing residents, particularly if implemented at the pace envisioned in the FAST scenario. Moreover, one analysis suggested that the market probably would not absorb the high proportion of multi-family dwelling units this scenario would require.

For these reasons the RAIL South scenario was dropped from analysis, although initial testing showed that it would produce significantly lower congestion levels for the same level of infrastructure investment, due to higher transit mode shares, shorter trip lengths, and more efficient use of transit.

A further variation of the theme expressed in the RAIL South scenario also was tested using the TRAVEL model. This variation, called the RAIL South Recentralized scenario, retained the RAIL South scenario within Montgomery County, but added to it a shift in housing locations outside the County so that within the same overall regional control total, less housing was assumed for Howard and Frederick counties and more for areas within the Beltway in Prince George's County and the District of Columbia. he results showed a reduction in auto congestion, but this scenario suffers from the same practical limitations as the RAIL South scenario.

Figure 5.9 shows the mix of new units by housing types for the RAIL and the RAIL South patterns when they are combined with the FAST economic scenario. As the fig-

FIGURE 5.5 **Jobs by Policy Area (FAST Scenario versus SLOW Scenario)**

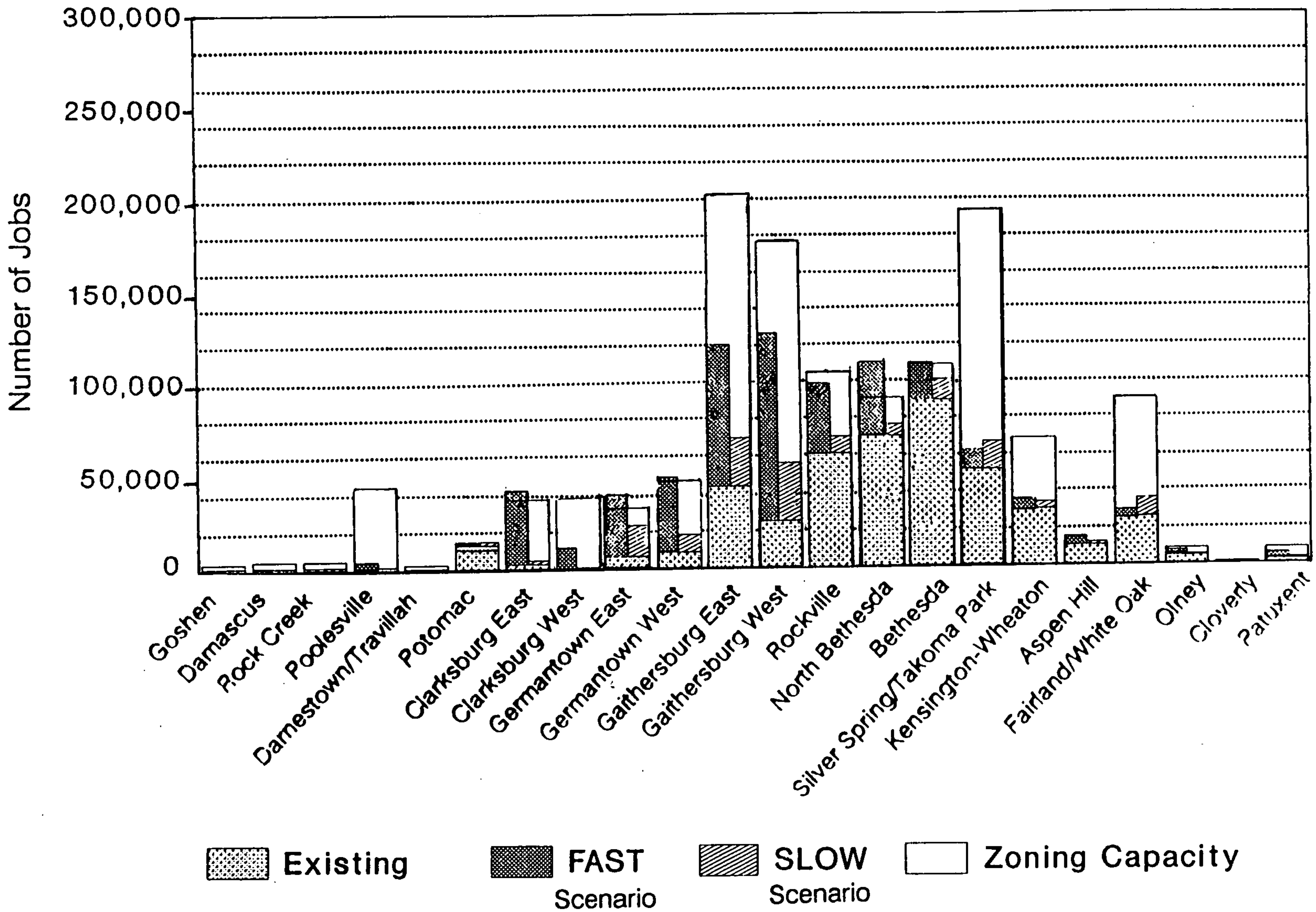


FIGURE 5.6 **Housing Units by Policy Area (FAST Scenario versus SLOW Scenario)**

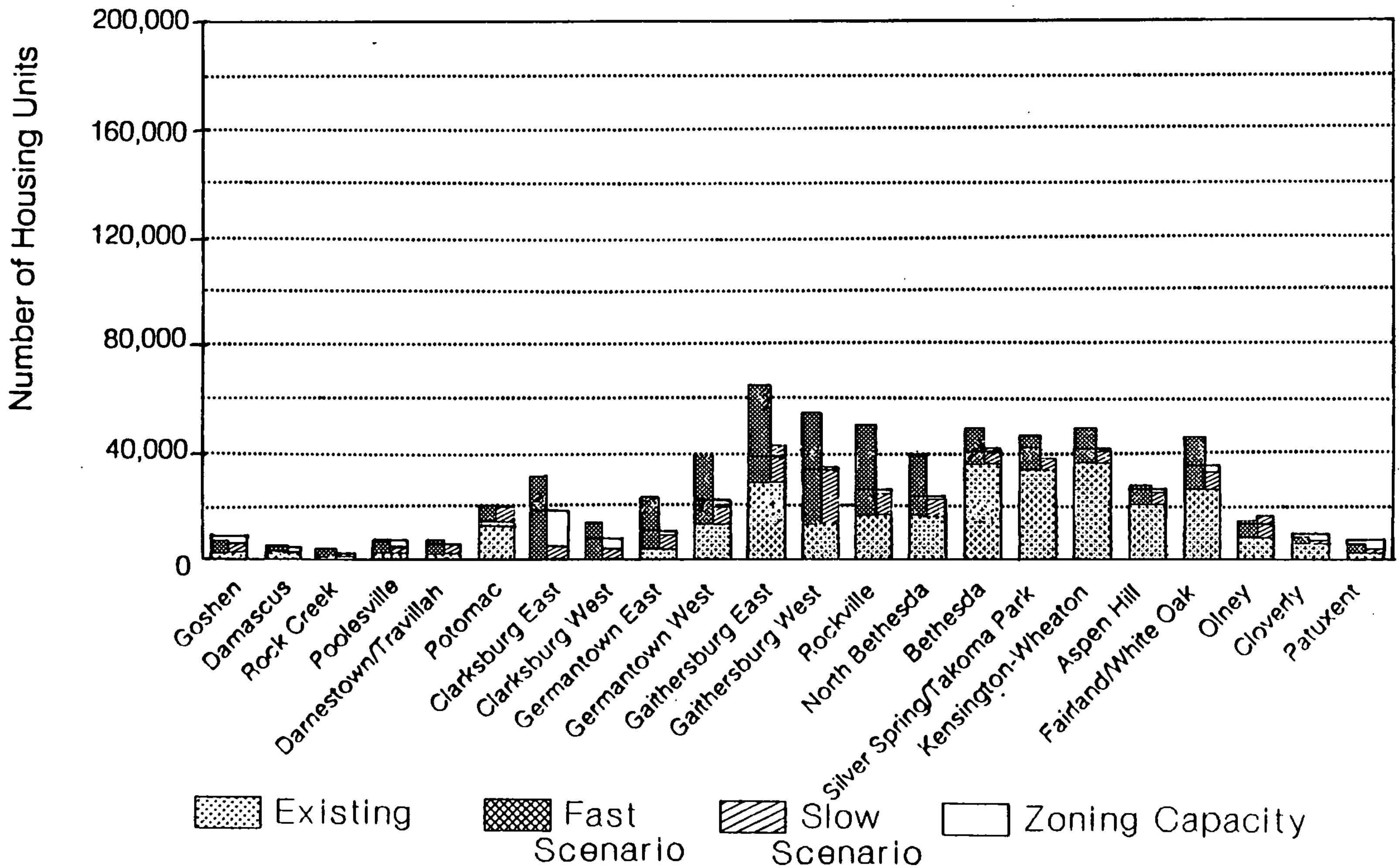


FIGURE 5.7 **Jobs by Policy Area (JOBS Scenario versus HOUSING Scenario)**

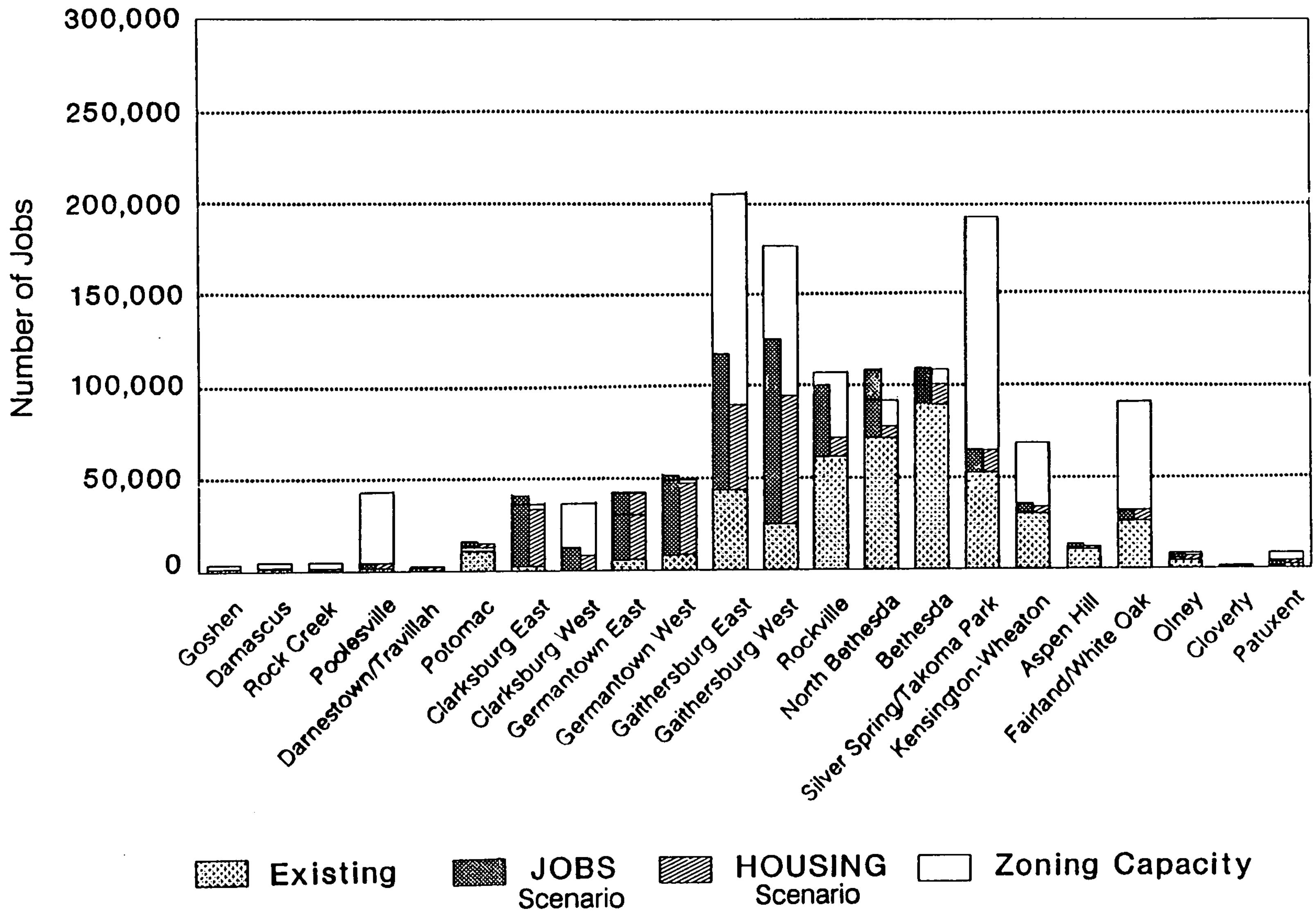
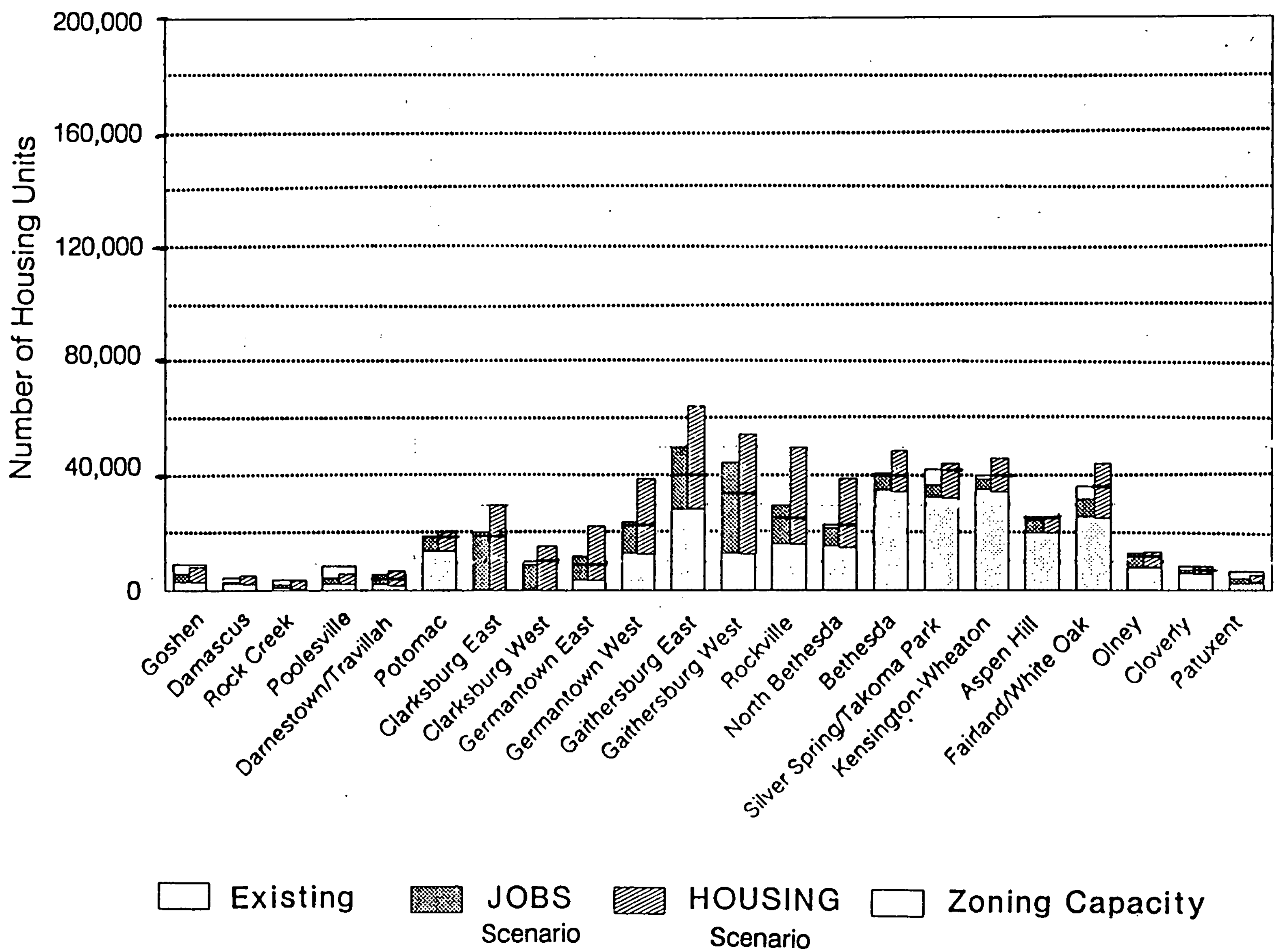


FIGURE 5.8 **Housing Units by Policy Area (JOBS Scenario versus HOUSING Scenario)**



ure indicates, the FAST/RAIL South scenario has fewer single-family houses and townhouses, and more garden apartments and mid- and high-rise buildings than the FAST/RAIL scenario.

To keep the same FAST scenario control totals, the increase in higher density jobs and housing in the FAST/RAIL South scenario must be fitted into less space than is used for the FAST/RAIL scenario. In order to judge whether or not this mix would be acceptable to the market, Figure 5.9 also shows the mix of housing types for several other situations. It looks at alternative demographic profiles for the County and shows how those profiles would be reflected in a preferred mix of housing types. Specifically, it compares the RAIL and RAIL South housing mixes to the housing mixes that would be desired by the future probable demographic profile of residents under normal market conditions. The comparisons change household demographics over time, but hold constant the percent of each housing structure type chosen by each household demographic sector (i.e., same as it is in Montgomery County today.)

The conclusion from these comparisons is that even a household demographic profile oriented towards high-density housing (i.e. more young adults, singles and elderly) would probably find the housing mix suggested by the FAST/RAIL and FAST/RAIL South scenarios unacceptably dense. However, changes in energy costs, economic conditions, and othr factors could cause the housing structure preferences of different demographic sectors to change from tohse of today.

The RAIL South pattern's housing type mix could be changed to a lower density profile (i.e., more single family units), and still be transit-serviceable if new light rail transit stops, serving primarily single-family houses and townhouses in the northern part of the County, were added. It also was assumed that with good design and appropriate amenities, including good access to transit, a market shift to higher-density housing could be achieved. The increasing number of new, high-priced, high amenity townhouses on the market supports this viewpoint. In summary, it seems probable that the RAIL South pattern mix of housing types could be amended from the one used in this Study and still be viable from a market perspective.

FIGURE 5.9 **Housing Types (RAIL/FAST versus RAIL South/FAST)**

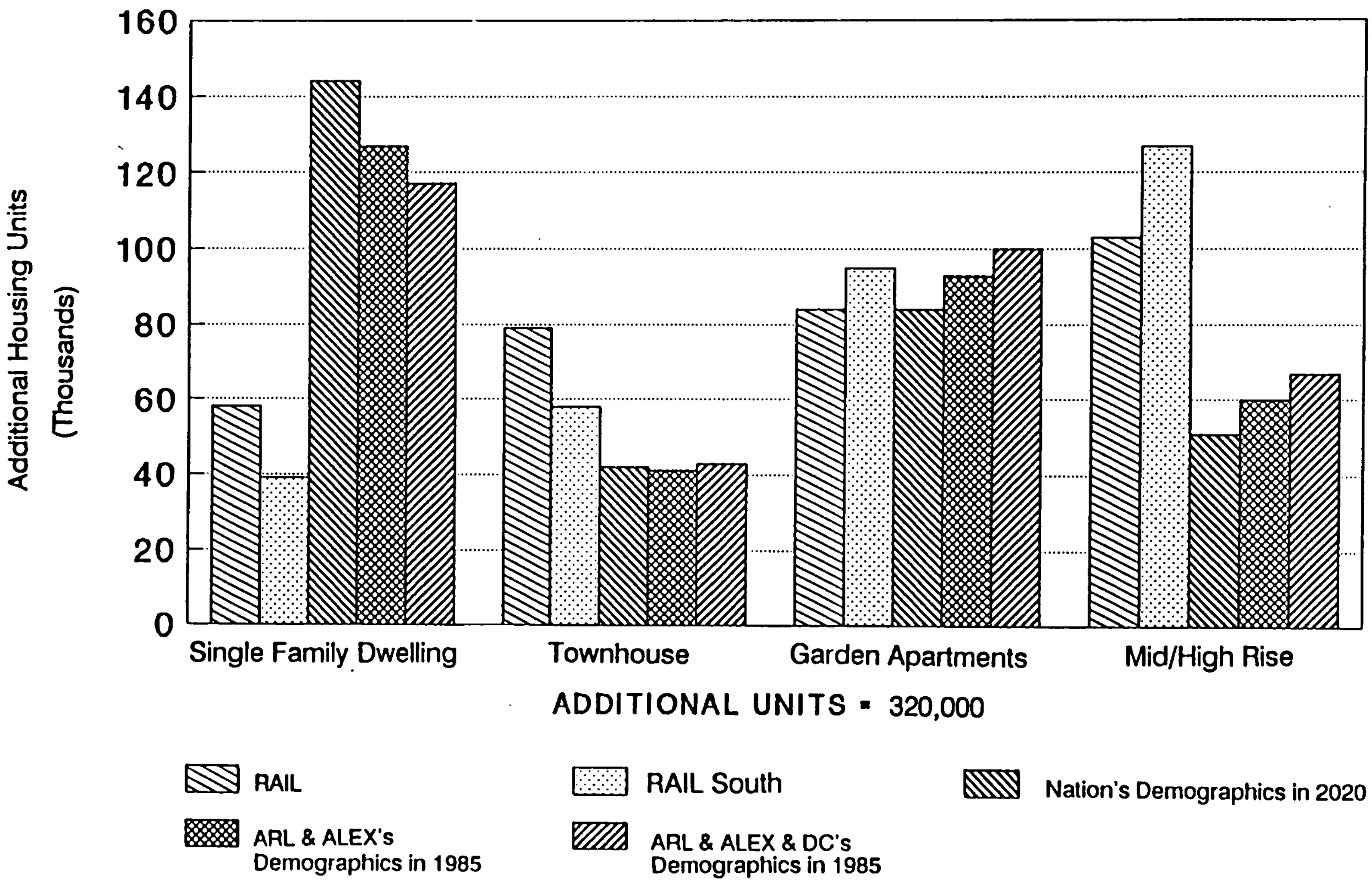
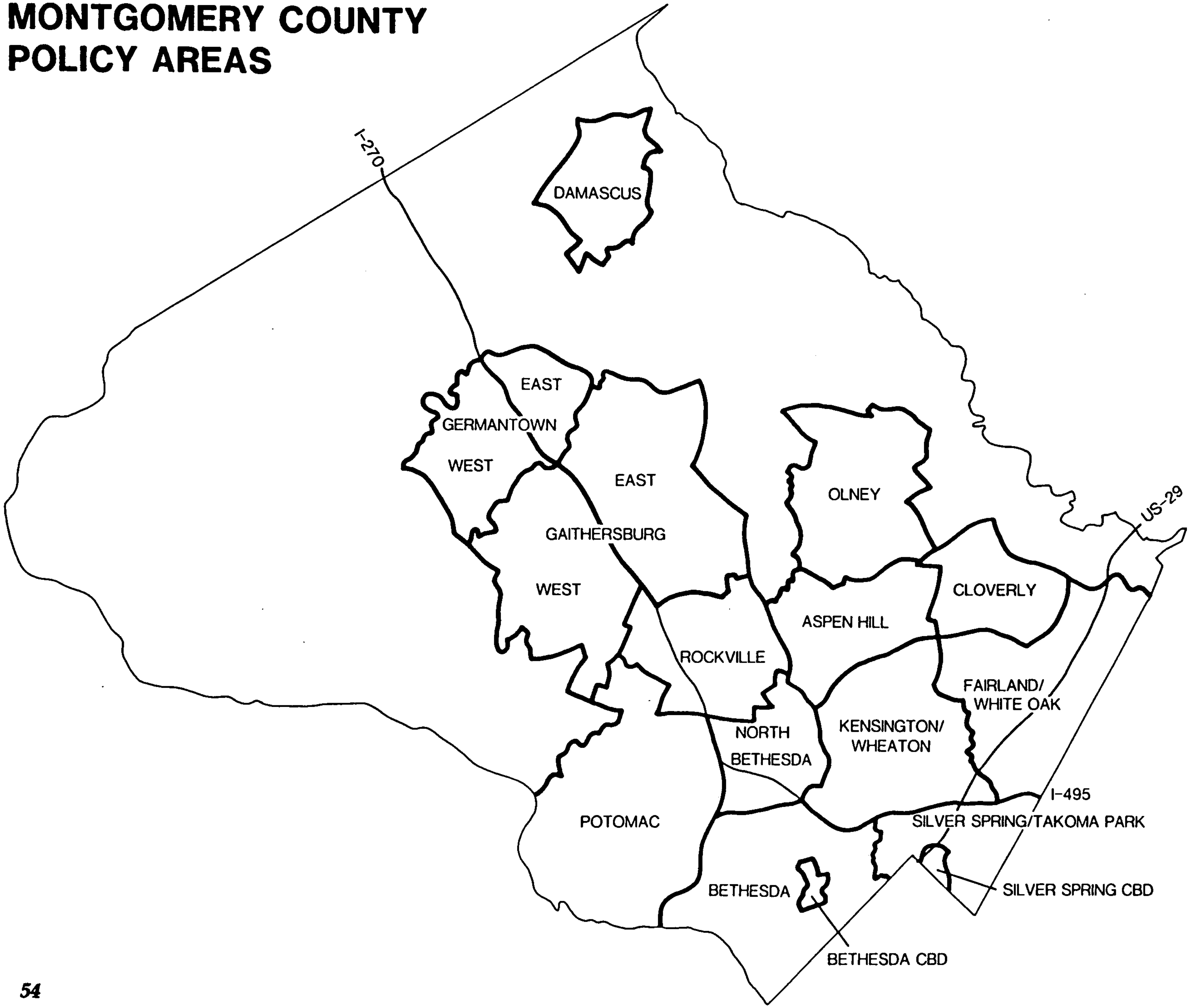


Figure 5.10

MONTGOMERY COUNTY POLICY AREAS



Chapter 6

Transit Incentives and Enhancements (Tie)

CHAPTER 6: TRANSIT INCENTIVES AND ENHANCEMENTS (TIE)

Section A: The Mode Share Submodel

A new mode choice modeling technique used for the CGP analysis makes the TRAVEL model sensitive to differences in numerous policy assumptions that affect mode choice. This submodel makes it possible to propose and test County policies with regard to what is called here the "TIE" package. An acronym for "Transit Incentive and Enhancements," TIE stands for actions that encourage people to shift from automobiles to transit. Figure 6.1 portrays graphically the factors that contribute to overall travel behavior, some of which the TIE package would deal with.

Sometimes called mode shift incentives, or traffic demand management techniques, the methods assumed in this Study are summarized in Table 6.1.

The prices, policies, and conditions prevailing in 1987 were used in the calibration of the new Mode Choice Submodel. Policies for each scenario can be expressed in terms of relative change from this base case condition. All user costs input to the Mode Share Submodel are expressed in 1987 constant dollars. Submodel inputs related to transportation pricing are generally altered from these base conditions only insofar as *user perceived relative costs* are assumed to change.

The Mode Share Submodel was discussed briefly in Chapter 2, and is also covered in Appendix 4.

Section B: Parking

Parking costs would be the same at the Weak TIE level as 1988 costs. The Moderate and Strong TIE levels would have parking costs much higher than in 1988, except for HOVs, which would enjoy free parking at the Moderate level.

Free parking has been cited by some transportation experts as a major transportation problem of suburban employment areas because it subsidizes and encourages automobile commuting. Montgomery County has already begun to move in the direction of higher parking charges in down-County central business districts (CBDs) to discourage LOV commuting. The parking charges assumed for all cars in the Strong TIE level and for LOVs in the Moderate TIE level vary by location and range from $2 to $12 a day. The highest charges are in pedestrian-friendly, transit-oriented CBD locations and lesser charges are in employment centers where transit services are less intensive.

These parking fees are assumed to apply only to all-day commuter parking. In contrast, hourly short-term parking rates would be low, so that non-peak hour travel to activity centers for shopping, business, or socializing by automobile would not be penalized.

As an aside, to the extent that these parking fees are charged by public parking garages or include excise

FIGURE 6.1 Travel Behavior Factors Relating to a Trip From Home to Work

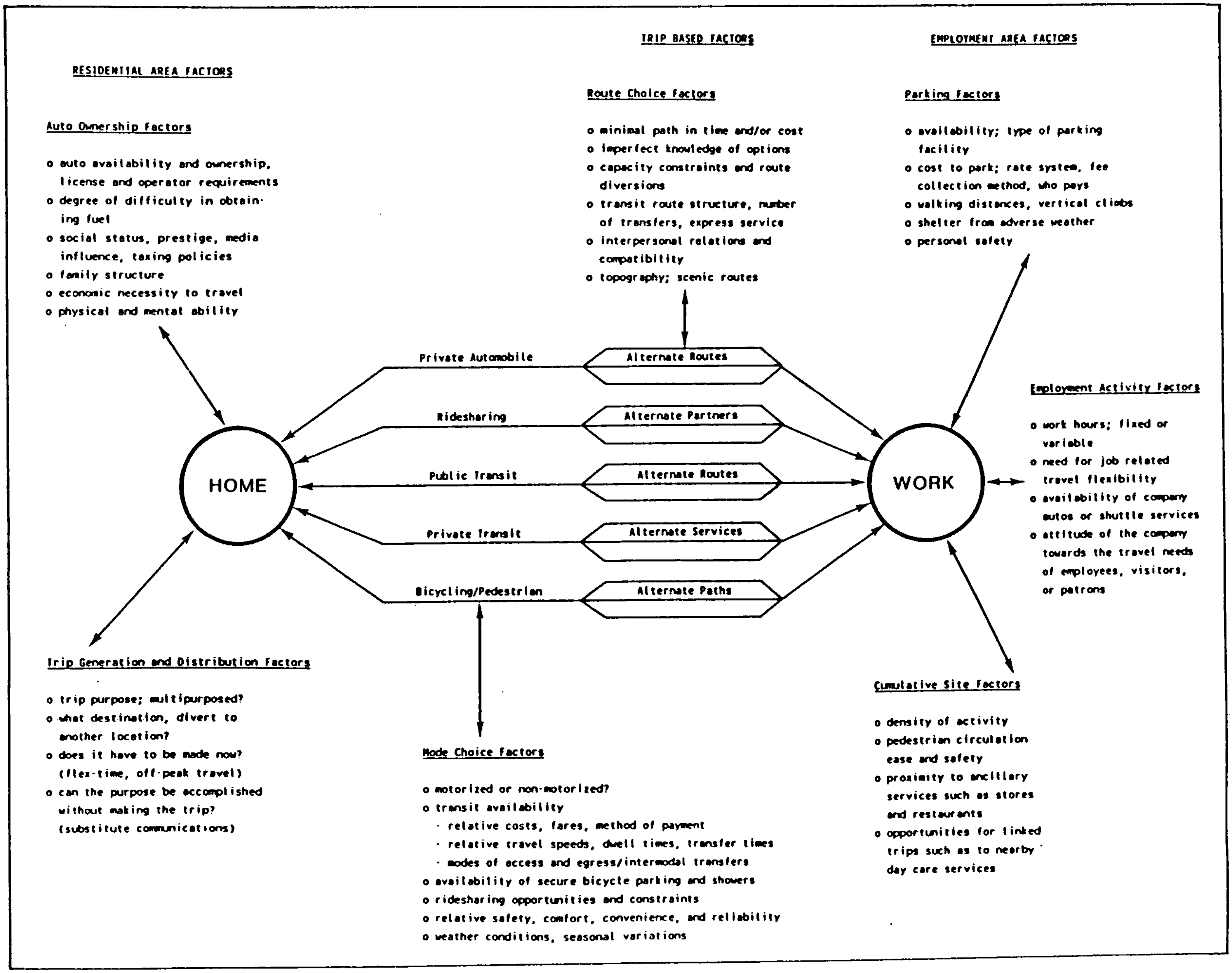


Table 6.1
THE TRANSIT INCENTIVES AND ENHANCEMENTS (TIE) PACKAGE
A Comparison of Mode Choice Factors Assumed for Travel Modeling

TIE Package Policy Option	Parking cost in Major Employment Centers	Automobile Operating Costs	User-Perceived Transit Fares	Quality of Pedestrian/bike Transit access	Household Auto-Mobile Ownership Levels	Park & Walk Time at Destination
WEAK (i.e., Current Policies	1988 Parking User Fees, e.g., Silver Spring CBD —$4/day Shady Grove West—$0/day Life Sciences Center—$0/day White Oak—$0/day	1988 Cost (0.15/mile)	1988 fares	Poor conditions in most of County except down-County CBDs	Somewhat higher than 1988 to reflect recent trends (2.2 cars/ household for County)	1988 conditions (2-3 minutes from parking to door)
MODERATE (used with VAN Scenario)	Free everywhere for HOVs Much higher for LOVs, e.g., Silver Spring CBD—$12/day Shady Grove West—$10/day Life Sciences Center—$8/day White Oak—$4/day	1988 Cost (0.15/mile)	1988 fares	Modest improvements in sidewalks, bike paths, and transit serviceable site planning	Same as 1988 (1.9 cars/household for County)	Same as 1988
STRONG (Used with RAIL Scenario)	Much higher fees for all autos, e.g., Silver Spring CBD—$12/day Shady Grove West—$10/day Life Sciences Center—$8/day	($0.30/mile) Higher gas tax and regulation fees	1/2 of 1988 fares due to equilization of commuter subsidies	Major enhancements in sidewalks, bike paths, and transit serviceable site planning in and near all growth nodes.	Slightly lower than 1988 for areas within walking distance of transit stations (1.8 cars/ household for) County)	Higher times in all growth nodes to reflect lower parking supply

taxes on private parking spaces in employment areas, substantial revenue could be generated. This could be used to finance better transit services, enhanced pedestrian and cyclist facilities, activity center amenities, and community services, or to reduce other forms of taxation that now pay for such things. The amount of revenue generated by higher parking fees, however, was not calculated or included in the fiscal analysis. Recent public discussion of a tax on private parking spaces has indicated that a $50/year tax on the County's estimated 500,000 private parking spaces would generate $25 million a year in revenue.

The analysis for both the Moderate and Strong TIE levels assumed that employers who provide free or subsidized parking will be required to provide employees with the option of receiving equally subsidized transit farecards or a sum in their paycheck equal to the market rate cost of parking. In addition, all employers will be encouraged to offer discounted transit passes to their employees as part of a commuter transportation management program.

These policies, known as "equalization of commuter subsidies," would help ensure that transit and the automobile are competing on a level playing field while still giving flexibility to employers and employees. Current employer-provided free parking is a large subsidy to LOV automobile commuting.

Finally, an element of both the Moderate and Strong TIE levels is to assume the County's zoning ordinance would be revised to require less parking for new development. Current County zoning, as well as Federal tax codes, encourages oversupply, which depresses market parking rates. The Federal tax code also makes it inexpensive for employers to offer free parking to their employees. The availability of free parking in turn makes it more difficult to attract enough transit riders to justify high quality, frequent services on public transportation. Equalization of commuter subsidies would reduce the need for public transit subsidy.

Section C: Auto Operating Costs

Automobile operating costs per mile would be the same as today ($.15/mile) at both the Weak and Moderate TIE levels, and twice as high ($.30) at the Strong level. This reflects higher fuel costs and/or higher taxes on fuels and vehicle registration.

There is considerable uncertainty about appropriate assumptions for automobile operating costs thirty years in the future. While the costs of petroleum fuels will almost certainly be much higher than today, vehicle fuel economy improvements and fuel substitution might counteract some of these increases. Nonetheless, taxes on motor vehicle fuels are subject to government action. The Moderate and Strong TIE assumptions are consistent with a future in which government would seek to raise taxes on fuels to discourage automobile use and the resulting problems of congestion, air pollution and the greenhouse effect. Volume 3, Global Factors, discusses these factors in greater detail.

Section D: Transit Fares

Peak period transit fares would be lower and simplified at the Strong TIE level.

Transit fares today in the Washington region are very complicated. Also, many people regard transit user costs as being too high. The Montgomery County Commission on the Future, for example, recently recommended free transit services for the County. Experience in other cities suggests that transit ridership might be increased more cost effectively by lowering fares and expanding service frequency, coverage, and diversity. As discussed earlier, the Strong TIE level already assumes all of these actions except lowering fares.

For simplicity, the TRAVEL model tests using the Strong TIE level presumed that users would perceive transit fares to be half of what they are today because of an equalization of commuter subsidies policy. Real transit fares might be the same as today, but user-perceived fares would be lower because employers would be required to pay employees who do not use employer-provided parking the cash equivalent of the market value of that parking.

Section E: Pedestrian and Bicycle Access

The Weak TIE level assumes that conditions for pedestrians and cyclists remain as they are today; the Strong level assumes that activity centers, transit stations, and access routes to them are safe and comfortable for pedestrian and bicycle traffic; and the Moderate level assumes the midpoint between these conditions.

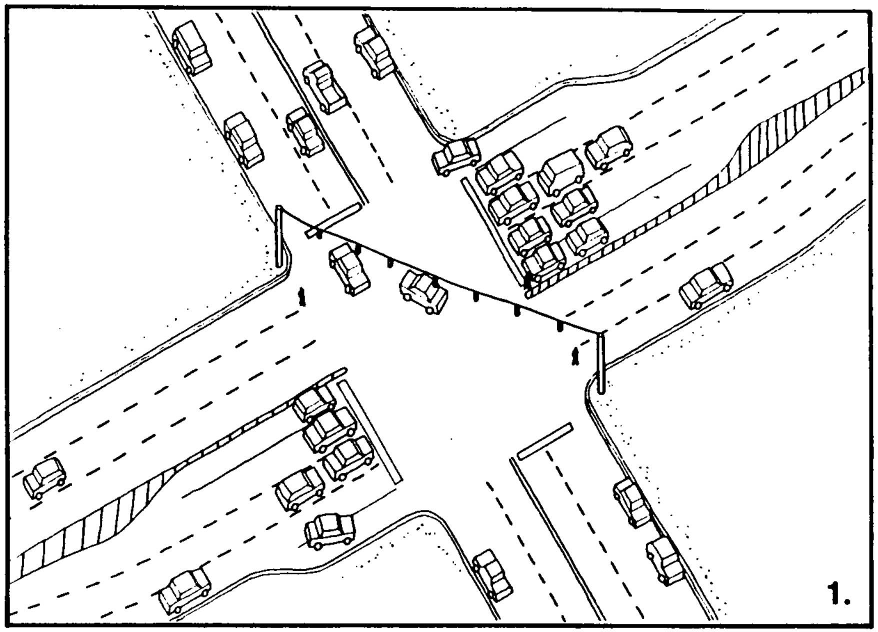
The likelihood that people will use public transportation is strongly influenced by how easy, safe and pleasant it is to walk to and from transit stops. Figure 6.2 illustrates the difference between an auto-friendly and a pedestrian-friendly intersection.

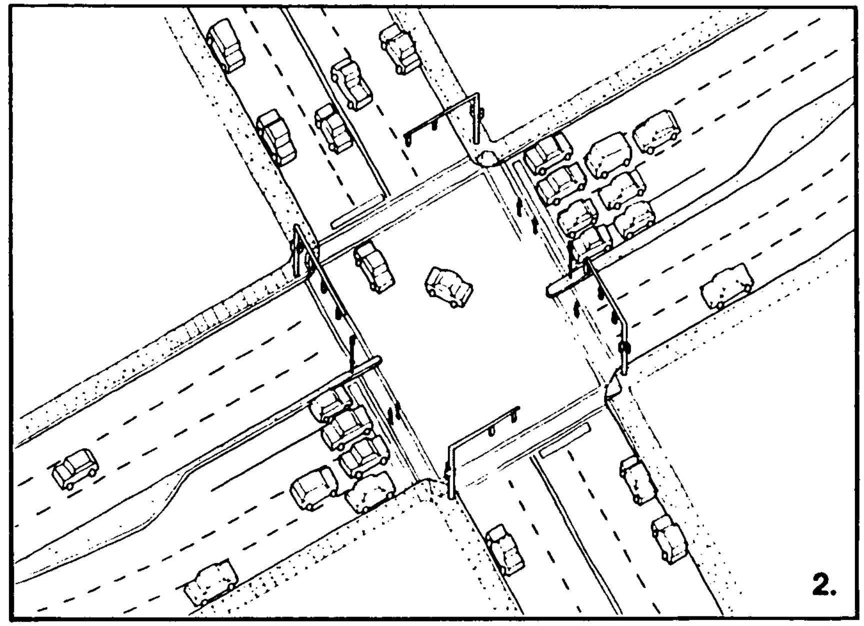
Extensive research has shown that if there are sidewalks and decent conditions for pedestrians, people, on average, are willing to walk a quarter of a mile to get to or from a bus stop and a half of a mile to or from a light rail or Metrorail station. In general, there is less tendency for people to tolerate long distances at the work end of their trip.

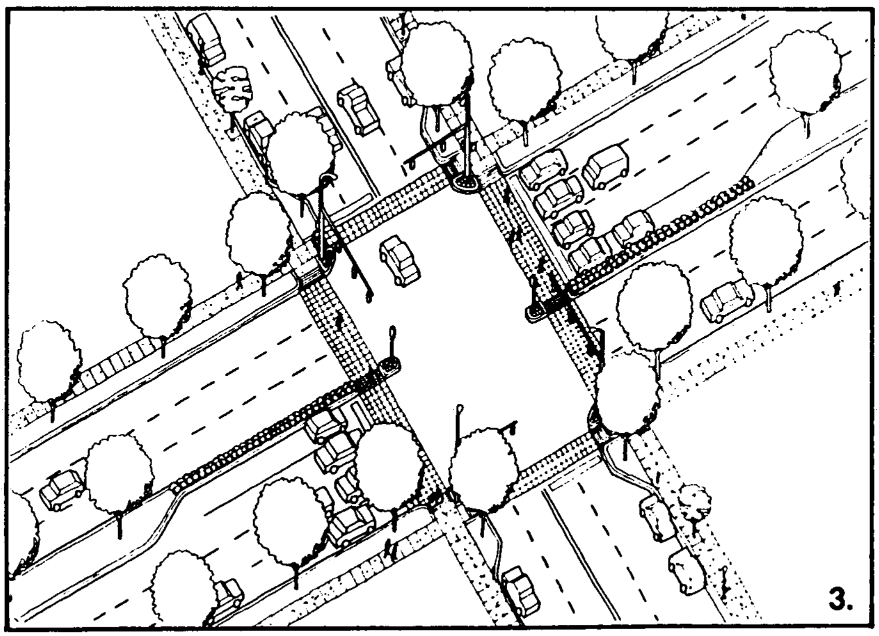
If there are no sidewalks and the general environment is not pedestrian-friendly, people will not walk nearly this far to get to or from transit. Similarly, research has shown that many people are willing to use bicycles to travel up to two miles to or from express transit stops, such as Metrorail or light rail stations, but only if there are safe and comfortable access routes and secure bicycle parking at the stations. If the environment is hostile to pedestrians and cyclists, and parking garages are provided at stations, this will encourage many people to drive to transit, to the extent that parking garage capacity can be provided.

The likelihood that many people will walk or ride bicycles for their whole trip to work is similarly a func-

FIGURE 6.2







PEDESTRIAN FRIENDLY INTERSECTION DESIGN

1. AUTO ORIENTED DESIGN (upper left) facilitates auto movement. The only intended connection between uses on different sides of streets is via the automobile. Note flaring of street for right turns which increases pedestrian exposure.

2. **MINIMAL PEDESTRIAN FEATURES (above) are sidewalks, handicapped ramps, crosswalks and crossing lights.**

3. **OPTIMUM PEDESTRIAN DESIGN (left) would also include street trees, articulated crosswalks and median breaks. On side streets where there is parallel parking, sidewalks can be extended out the width of the parking lane to shorten street crossing distances for pedestrians.**

tion of whether the environment is pedestrian or bicycle friendly. In many European suburbs and cities, 20 to 40 percent of all person trips are made by walking or cycling, compared to less than 5 percent in Montgomery County today. Obviously, if land use is more compact and mixes jobs and housing, it encourages shorter trips and also favors more use of walking or cycling for the entire work trip.

The importance of bicycles in increasing the number of people who have access to a transit station is illustrated in Figure 6.3. As it indicates, the maximum distance that significant numbers of people will walk to a transit station is generally accepted to be a half mile. The average distance significant numbers of people will cycle to work is generally accepted to be two miles, as indicated by the 1983-84 National Personal Transportaton Survey. As the diagram shows, bikes provide a transit station with a catchment area in square miles that is 16 times larger than the pedestrian access area. Unlike autos, bikes do not create insoluble parking problems near rail station. Unlike buses, they do not get caught in automobile congestion on their way to the station, assuming there are reasonable bike paths.

The Strong TIE level assumes very pedestrian- and bicycle-friendly environments for all areas of moderate- to high-density development. This will require a substantial investment in sidewalks, bicycle paths and lanes, and traffic signals designed to give some priority to pedestrian and cycle traffic. Specifically, within a half mile of all Metro and light rail stations there would be sidewalks on all streets, and longer walk signals. To the extent feasible, there would be a reduction in the use of flared intersections, and preservation or creation of median strips in arterial roads wider than four lanes. There would also be safe and convenient bicycle routes leading to stations and to major activity centers and providing circulation within these centers.

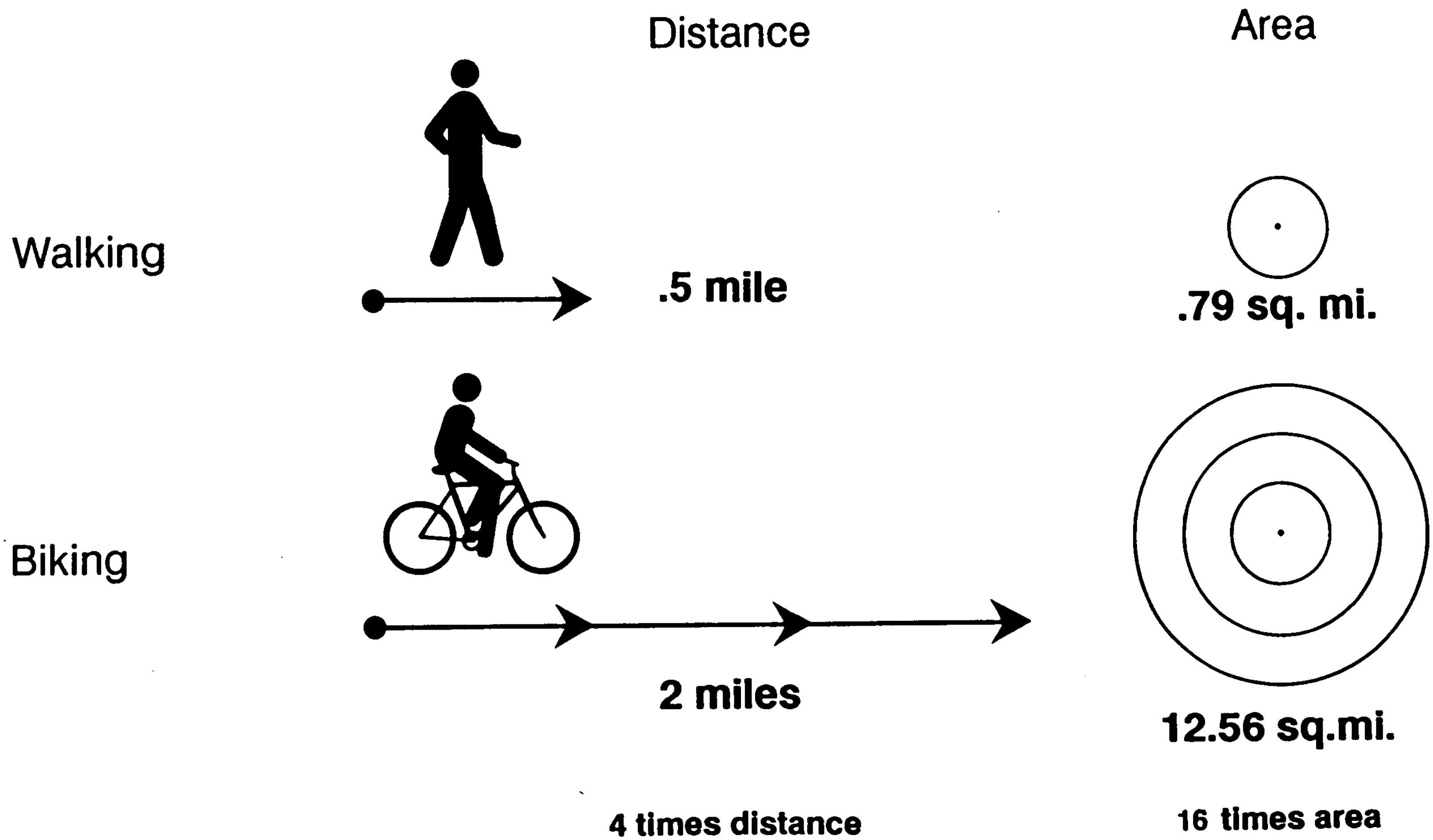
Pavement textures and networks, chokers, speed bumps, traffic diverters, and other traffic management and street design treatments would be used to provide a higher level of pedestrian and bicycle priority for road crossings in the vicinity of activity centers and transit stations.

Covered and guarded bicycle parking would be provided at major stations, as is very common in Europe and Japan, to eliminate problems of theft and vandalism. This will also make it easy for people to leave expensive bicycles at the station overnight, for use in getting from stations to nearby employment.

For existing single family subdivisions that are more than a half mile from stations, there would be improved bicycle trail connections to transit stations, since other means of providing access to stations require either high bus subsidies or high parking subsidies. Figure 6.3 illustrates how important such bike trails can be in increasing the non-vehicular catchment area of a transit station.

FIGURE 6.3

Pedestrian and Bike Transit Access Distance



Section F: Bus/HOV Serviceable Site Planning

The municipality of Ottawa-Carleton in Ontario has introduced transit serviceability guidelines that re-orient residential development so that it can be well serviced by bus. A copy of the basic principles of what this area is doing is included as Table 6.2.

Principles similar to those developed in Ottawa-Carleton, if applied here, would effectively preclude, for example, a current common problem in Montgomery County's single family neighborhoods. Houses are too far from bus stops to walk even when the distances as a crow flies is short. The problem is a lack of pedestrian paths between neighbors' homes to provide access to the bus stop on an arterial road.

The principles of transit serviceable site planning have already been incorporated in the revision of the regulations for the County's I-3 zone. For example, the I-3 Zone will now require that buildings be placed next to the road, with parking behind them, so that walking distances for transit riders are shorter. It will also require, under certain circumstances, that convenience retail be provided on site so that workers can take care of daily errands without a car, thereby removing a major objection for not using transit.

Similar site planning principles are outlined for single family and commercial development in Appendix 5, Bus/HOV Serviceable Site Planning. It is assumed that those principles would be applied at both the Moderate and Strong TIE levels.

TABLE 6.2 Subdivision Transit Guidelines in the Regional Municipality of Ottawa-Carleton

Principles

a. Minimize overall walking distances by:
1) appropriate location of the collector roadway system to be used by transit;
2) provision of paved walkways;
3) placing all high-density developments on the streets serviced by transit; and
4) placing all medium-density developments on streets carrying transit, or in closer proximity to such streets than low-density development.

b. Minimize the number of streets in which transit service is provided.

c. Concentrate as many transit routes on the same street, to provide the highest possible level of service in terms of headway to all users.

d. Minimize transit route lengths through the development by providing a collector road system that permits as direct as possible routings in the orientation of heaviest demands.

e. Link sufficient neighbourhoods by one service to ensure that attractive headways can be efficiently provided during both the peak and off-peak periods.

f. Develop a transit route structure that lends itself to the minimum number of routing changes through the development stages.

Conditions

a. The requirement for adequate construction depth, roadway geometrics, paved passenger standing areas and a minimum of a sidewalk on at least one side of the street on all streets carrying transit.

b. Orientation of buildings and private accesses adjacent to the stops.

c. The provision of paved all-season walkways through open areas and between streets to minimize walking distances.

d. The provision of transit-only roadways.

e. The distribution of land uses.

f. The developer must enter into an agreement with the municipality regarding the staging of development. These agreements, which also take into account automobile needs, may include a required sequence of construction, temporary roadways for transit access and the completion of essential roadway links prior to habitation of particular phases, plus any other measures that may be appropriate.

Source: Regional Municipality of Ottawa Carleton, **Transit Servicing of New Areas - Guidelines for Development** (Ottawa: RMOC-Transportation Planning Division, December 1981).

Chapter 7

Analytic Tools: Travel and Fiscal

CHAPTER 7: ANALYTIC TOOLS: TRAVEL AND FISCAL

Section A: The TRAVEL Model

The Study relies on a traffic simulation model called TRAVEL to develop and evaluate the effect of the scenarios on traffic congestion, and a budget simulation model, called FISCAL, to develop and evaluate the impact on the County's budget. TRAVEL is a forecasting tool that has been used to simulate travel behavior for the morning peak hour of traffic, considering transportation system capacity, land use that generates transportation demand, and public policies that influence people's choice of travel mode. TRAVEL is the name given to the latest version of the transportation model used to help evaluate the Annual Growth Policy and has been developed within the framework of the EMME/2 computer software. FISCAL uses the framework of a fiscal accounting software package called MUNIES, hand tailored to the needs of Montgomery County and this Study.

How TRAVEL Works

The TRAVEL transportation modeling procedure incorporates four basic steps: (1) generating trips by traffic zone, based on land use; (2) distributing trips between traffic zone pairs, based on relative travel time among all the zone pairs; (3) estimating mode shares for each origin-destination pair, based on travel time, cost, and public policies; and (4) assigning estimated vehicle trips to existing and planned roads and transit lines, while accounting for and estimating congestion on the networks.

The TRAVEL model's basic building blocks are traffic zones. These serve as the origins and destinations of trips. For this Study, some of the usual 246 Montgomery County traffic zones were subdivided to produce a total of 285, in addition to the 90 zones that represent the remainder of the Washington region. In many cases, the reason for the subdivision was to reflect, for the purposes of this Study, the location of possible new development near projected new transit stations.

The TRAVEL model uses data on the location of households and jobs by zone to generate estimates of home based work trip "productions" from homes and work trip "attractions" to jobs. TRAVEL also generates estimates of non-work vehicle trips, for shopping and other purposes, and truck trips, using the same land use data—although they form a lesser part of the traffic in the morning peak hour.

TRAVEL then uses a technique called a "gravity model" to distribute trip "productions" to "attractions." This mimics the law of gravity, where the force of gravity is directly related to the mass of the objects and inversely related to the distance between them. In TRAVEL, the likelihood that people will travel to a destination is related to the relative attractiveness of that destination compared with all other destinations and inversely re-

lated to the travel time between the destinations. This process produces "trip tables" describing travel between zones.

Next, for work trips only, TRAVEL evaluates relative travel time and cost on the input transportation networks and also considers other public policies that can affect the economics of conveniences of transit. It then estimates how people will travel to work—by walking to transit, driving to transit, driving alone, or driving with passengers. This can be used to produce both a trip table for vehicle work trips and estimates of mode share results for work trips.

TRAVEL then estimates how daily traffic demand will translate into morning rush hour traffic demand, based on the input land use data. Model calibration and research have shown that the more clustered and heterogeneous the development at a small scale, the lower the percentage of daily trips made in the morning peak hour. Lower density homogeneous land use patterns thus produce more peak hour vehicle trips per unit of development than higher density mixed use patterns, and this is reflected in the model.

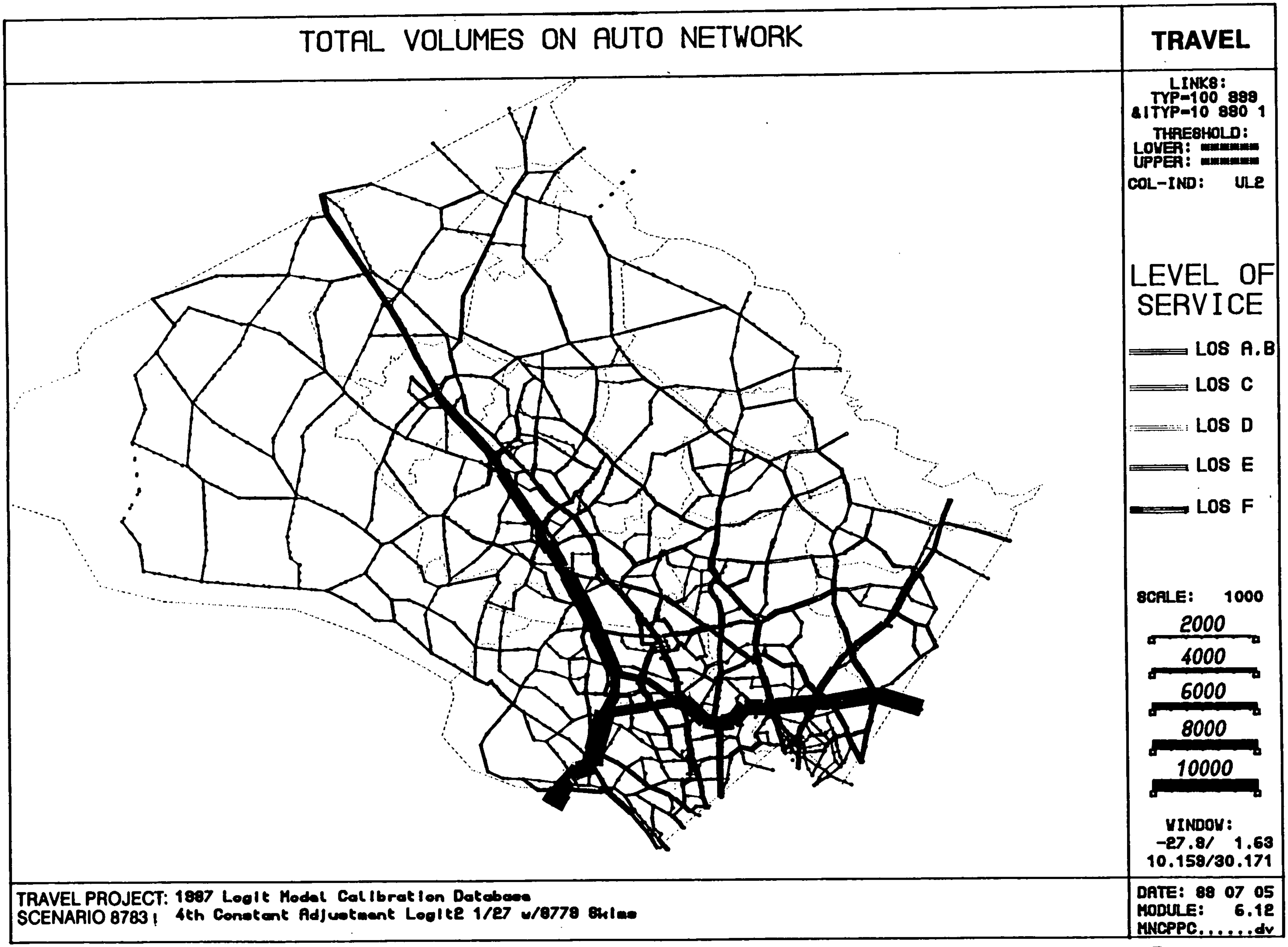
TRAVEL then assigns the morning rush hour vehicle trip table to the road network, taking into account traffic congestion and seeking to minimize the total delay in the network using EMME/2's linear programming and optimization techniques.

For the purposes of this Study, the most important product of TRAVEL is estimates of congestion on highways, expressed as level of service. Figure 7.1 is a black-and-white reproduction of a color map produced by TRAVEL which shows traffic volumes and traffic congestion by band color and width. TRAVEL also summarizes this information numerically, weighting congestion levels by the vehicle miles of travel on each road segment so that the average congestion level for policy areas or for the County as a whole can be calculated.

TRAVEL has been calibrated using data on transportation demand from the 1980 U.S. Census and a 1980 Metropolitan Washington Council of Governments Auto Use Survey, as well as data on land uses and morning peak hour traffic counts from the late 1970s to the present. Much of the model structure is borrowed from regional travel demand models developed and maintained by the Council of Governments. The new mode choice model has been calibrated by the Montgomery County Planning Department on household travel survey data collected in 1987-1988 by the Council of Governments.

Except for the new mode choice model, the process of calibrating TRAVEL was documented in chapter seven of the Montgomery County Planning Department's December, 1987 report, *Alternative Transportation Scenarios and Staging Ceilings.* The mode choice model calibration has been documented in a technical memorandum presented to the Montgomery County Transportation Modeling Technical Advisory Commit-

FIGURE 7.1 Example of Map Produced by TRAVEL



tee in March 1989. The Montgomery County Planning Department regularly consults with this Advisory Committee regarding changes in model structure and details of modeling methodology to help ensure that sound approaches are followed.

Limitations on TRAVEL

The limitations of using TRAVEL, or any similar model, to make long term projections must be noted, as well as a limitation on the model due to lack of data on incomes and salaries by locations.

When run with appropriate land use and network data for 1980 and 1987, the model generally estimates average traffic congestion levels and vehicle miles of travel by policy area within five to ten percent and shows good stability of performance over this time frame. When the model is used for longer range forecasting, confidence in the model is necessarily less. However, the model is based on a number of common sense relationships between factors and can provide a valuable gaming board for evaluating complex land use-transportation balance questions as well as to begin considering policies affecting the economics and convenience of using different forms of transportation.

When a model is used to make long term projections, many assumptions must be used in place of observed data, and these assumptions are assumed to hold over long periods. In addition, there is no reliable long term data from the past with which to calibrate the accuracy of long term projections. As a result of these problems, the results produced by the model should best be seen as relative indicators of future conditions.

A particular limitation of TRAVEL that should be noted is that it has been calibrated to match the current observed network of work trip origin-destinations by using area-specific socio-economic adjustment factors. Without such factors, the travel networks simulated by the travel-time-based gravity model do not match networks of commutation observed in various censuses. Without such adjustments the model would not account for the disproportionate number of commuters from Prince George's County to Montgomery County. Nor would it account for the disproportionately large number of high income workers who commute from Potomac to the District of Columbia. Only by using these socio-economic adjustment factors can the model represent today's reality, but these factors are probably unstable over a thirty-year period.

It is hypothesized that one of the factors leading to this situation relates to issues of housing affordability. Strong policies favoring affordable housing near jobs, for example, could likely have a significant effect on traffic congestion and travel demand over a period of several decades by shortening average work trip length. Unfortunately, at present, the TRAVEL model cannot yet represent such income-driven effects. Very preliminary steps to address this problem are getting under way through the Council of Governments at the request of the Planning Department, but additional data collec-

tion on income distribution, housing affordability, and their relation to travel behavior is needed to get to the heart of the problem.

The Mode Share Submodel

A major improvement to the TRAVEL for this Study is the addition of a mode share submodel. This model, which is a component of the larger model, reflects the factors known to affect mode choice, such as walking distance to a station, ownership of a car or second car, cost of parking, quality of the environment for pedestrians and cyclists, and transit fares. The importance of the mode share model is that it makes possible much better estimates of the number of people who will be attracted to use transit and what alternatives they will use. A critical component of this Study is to help analyze the potential mode shift from different transportation networks. As such, the use of the new Logit Mode Share Submodel is a major improvement over former methods of forecasting mode shift. The development of the Logit Mode Share Submodel is explained in more detail in Appendix 4.

Section B: The FISCAL Model

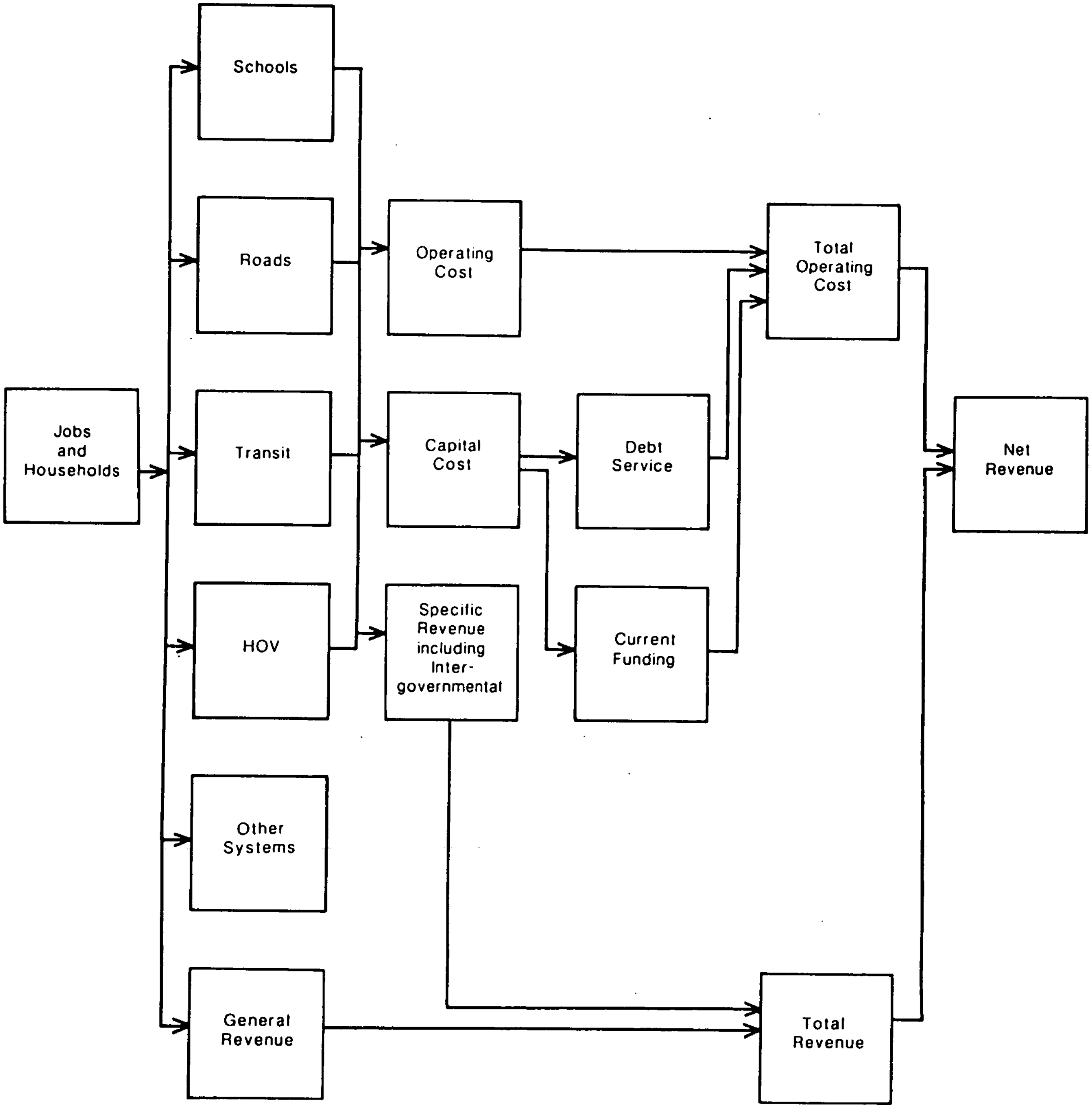
The FISCAL model assesses the economic or cash flow impact on the County of different amounts and locations of development. FISCAL was developed for the purposes of this Study using the MUNIES fiscal impact modeling software. Figure 7.2 is a schematic of how the land use and cost and revenue elements relate in FISCAL.

How FISCAL Works

In this Study the FISCAL model is used to simulate the annual cost/revenue situation that would occur in a horizon year, in this case 2020, under the conditions established by a given scenario. Debt service costs for the horizon year are assumed to be an average of the intervening years between the present and 2020. Operating costs for health, welfare, and safety functions are derived from present data on a per capita or per job basis. Costs for schools and transportation are custom tailored to fit each scenario. FISCAL intentionally is used to focus on the fiscal impact of changes in transportation systems and changes in school costs because they are the major County costs that change with growth.

FISCAL looks at how growth in housing and jobs affects both demand for services and sources of revenues. Different kinds of homes and jobs generate different service demands and different revenues. For example, single-family houses produce more school children than apartments, but they also pay more taxes. Office jobs produce more in property taxes per job than industrial jobs. To reflect these differences, FISCAL uses four housing types and four employment types. The four housing types are single-family, townhouse, garden apartment, and mid/high-rise apartment. The four employment types are office, retail, industrial, and hotel/institutional.

FIGURE 7.2 CGPS Fiscal Impact Schematic



Finally, the assessed value of both houses and commercial buildings varies with their location in the County. To reflect this variation, the County was divided into five separate areas. A new house or a new job is assumed to have different costs and produce different revenues in different parts of the County based on those differences as they exist today. The five different sub-areas are shown in Figure 7.3.

In summary, each housing type for each of the five sub-areas has an average assessed value, average household size, and average income, which are used to generate cost and revenue figures. Similarly, each employment type for each of the five sub-areas has an average assessed value and number of square feet per employee, which are used to generate cost and revenue figures.

All of the characteristics of new homes and jobs, such as average assessed value, were assumed to be the same in the scenario projections as they were in the FY 1988 base year.

Operating Costs

Operating costs for the County, other than those for schools or transportation, were taken from the County's FY 1988 Budget, and calculated in constant dollars. The budget costs were calculated on an average per capita, per household, or per job basis. For example when costs for a department reflected the number of people in the County, the department's budget, was divided by the 1988 County population to get an average cost per capita. When a department had revenues specifically dedicated to that department, such as fees, fines and intergovernmental grants, they were deducted from costs in FISCAL to produce a net cost.

As noted earlier, schools and transportation costs were calculated independently. School operating costs will be affected by the nature and location of development. Denser development, for example, with more high-rise apartments, will tend to produce fewer students per household and therefore, lower school operating costs. Transportation operating costs will obviously vary with the type of system proposed.

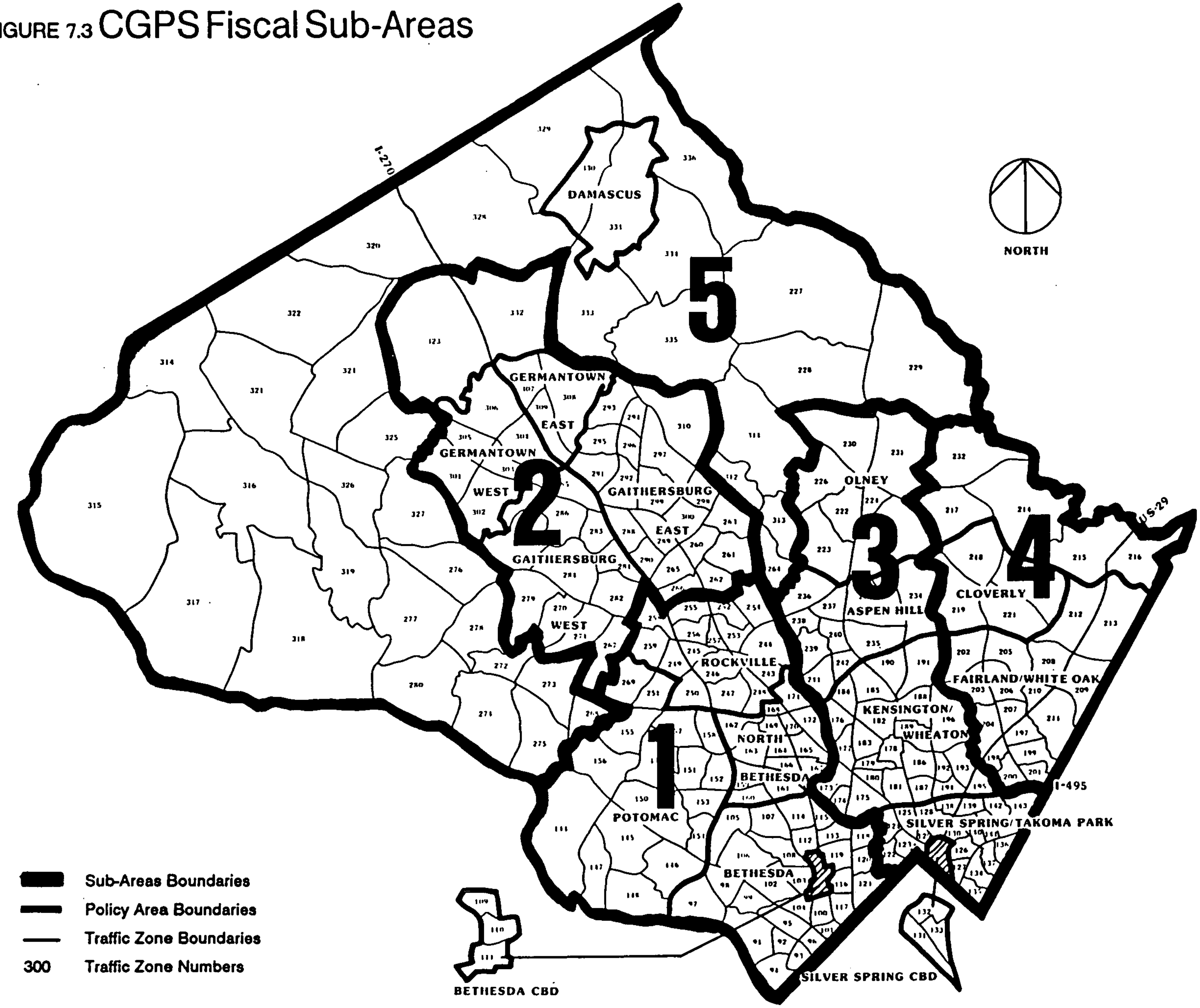
Once the per capita and per job figures for operating costs were developed, they were run through the FISCAL model. This run of the model was to ensure that the base figures were correct, in the sense that FISCAL could use them to reproduce the Budget figures they were taken from.

Capital Costs

Capital costs, other than for transportation and school facilities were based on a four-year average of costs in the CIP. The average annual per capita and per job capital costs were calculated for the four-year period and this cost was used as the capital cost in the horizon year 2020.

To estimate capital costs for schools and transportation for the horizon year, a total thirty-year cost for capital

FIGURE 7.3 CGPS Fiscal Sub-Areas



was developed. Since the horizon year is thirty years out and projects are typically funded with twenty-year bonds, the total capital cost for facilities to serve new jobs and housing over thirty years was multiplied by two-thirds. The average annual cost for bonding that amount over twenty years at 8 percent interest was then calculated. Using this procedure avoids having to predict the schedule of capital spending over thirty years.

Revenues

All County taxes were included in the FISCAL model. As implied earlier, estimates for them were based on four housing types and four employment types for five sub-areas of the County. The FY 1988 figures for each tax was developed for each housing type and employment type by sub-area. As with costs, it was assumed to be constant throughout the thirty-year period.

* The property tax, the transfer tax, and the recordation tax revenue estimates were based on assessed values from the Assessor's parcel file. Only employment estimated to be in tax paying buildings generates property, transfer, and recordation taxes. Other employed people, consisting mainly of government workers, construction workers, self-employed persons, and persons assumed to work at home, generate only energy and phone taxes.

* Business personal property tax revenues are estimated from the assessed real property value of employment facilities.

* Income tax revenues are based on household incomes by type and area from the 1987 Census Update sample survey, projected to 1988, and calibrated to FY 1988 County income tax collections.

* Energy tax revenues are based on estimated square feet of building for the four housing types and four employment types.

* Phone taxes are based on estimated phone lines per worker and per household.

School Costs

The Demographic Model used numbers of projected new housing units and aging and migration patterns for single- and multi-family housing by planning area to produce estimates of school age children for the horizon year. Estimates of public school enrollment and the costs of new school needs were then developed based on private/public student ratios, existing capacities, size of schools, and costs of schools. These numbers were provided by Montgomery County Public Schools staff.

It should be noted that the ratios of school age children by house type do not change as land use networks change from the AUTO, to RAIL, to VAN networks. For example, a mix of more dense housing and, therefore, fewer single-family houses, results in fewer school children. As a result, the more dense land use scenarios, in particular those assumed for transit where proximity of homes to stations is critical, have fewer children.

They, therefore, have lower school costs and appear better fiscally.

In practice, if the mix of new housing available in the County were more dense, more families might choose to raise families in townhomes and other denser housing types. As a result, the RAIL networks, with their denser housing, probably look better fiscally than they would in practice.

Water and Sewer

The Washington Suburban Sanitary Commission's budget is separate from the County's. It pays for new facilities out of fees paid directly to it. As a result, it was not included explicitly in the fiscal modeling exercise. Chapter 9, however, discusses future needs for new waste treatment capacity and their fiscal implications.

Chapter 8

Cost Estimates for the Transportation Networks

CHAPTER 8: COST ESTIMATES FOR THE TRANSPORTATION NETWORKS

Section A: Background

Figures 8.1 and 8.2 summarize the capital and operating costs for the different transportation scenarios. They show, as discussed earlier, that the Master Plan of Highways will be built out in each scenario, and that highways are, therefore, the largest cost component of each scenario. The cost figures for the RAIL scenario assume the amounts of development in the FAST economic scenario, costs for the AUTO scenario assume development as in the TREND benchmark, and costs for the VAN scenario are scaled up from TREND. In addition, Figures 8.1 and 8.2 show how important State and Federal funding is to the implementation of any of the transportation strategies. The likelihood of changes in State and Federal funding levels is discussed in Section E.

It should be emphasized again that the transportation networks are intended to show the strengths and weaknesses of relying on the car, relying on HOV facilities and relying on light rail. In practice, the County will probably try to achieve the best mix of all three. It is possible that a few highways in the Master Plan of Highways will not be built, and probable that some or many components of the VAN and RAIL scenarios will not be built. It is also probable that the County's future transportation system will include both light rail and HOV elements. The intent of this Study, however, is to illustrate different strategies, not to define an ideal one.

Section B: Transportation Costs for the AUTO Scenario

The full extent of the future highway system in the County is shown on the Master Plan of Highways. This plan contains all of the significant roads planned to serve future development of the County. Additional local or subdivision roads to serve neighborhood development are not shown. These local or subdivision roads are planned and paid for, as part of that development as it takes place.

Roads in the Master Plan of Highways are built through the County Capital Improvements Program (CIP) and the Maryland Department of Transportation's Consolidated Transportation Program (CTP). State roads are typically the most important routes. They serve interstate and intra-regional travel and include the Interstate system. They are funded through the State Transportation Trust Fund from gasoline taxes, corporate income tax, and user fees. A significant proportion of them is usually funded by federal aid, which is allocated to Maryland from the gasoline tax collected by the federal government.

Table 8.1
COST OF THE HIGHWAY NETWORK
{Figures are current dollars in millions}

	(1)	(2)	(3)	(4)	(5) (2+3+4)	(6) (1+5)
		State Roads				
Highway Capital Cost Category	County Roads	Secondary {MD Routes}	Primary {US Routes}	Interstate	Total State	State & County
Master Plan of Highways Buildout beyond State and County Programs	579	1,162	370	82	1,614	2,193
FY 1990-95 County CIP	381	89	72	0	161	542
FY 1990-94 State CTP	0	153	216	478	847	847
Subtotal	960	1,404	658	560	2,622	3,582

Table 8.2
BUS OPERATING COSTS

Transportation Pattern	Ride-on and Metrobus Miles Per Year (in millions)	Average Operating Cost Per Mile	Estimated Annual Bus Operating Costs (in millions)
AUTO	34.9	$4.22	$147 (98 Ride-On) (49 Metrobus)
VAN[1]	36.6	$4.22	$154 (103 Ride-On) (51 Metrobus)
RAIL[2]	41.9	$4.22	$178 (119 Ride-On) (59 Metrobus)

NOTES:
1. 5% increase in service over AUTO.
2. 20% increase in service over AUTO.

The County funds County roads primarily through general obligation bonds and impact fees, as well as developer contributions. In recent years the County has begun funding part or all of some planned State roads and State road widenings. The County has provided this funding because State resources have not kept pace with the need for developing and improving State routes in the County. Budget action this year, however, reduced County funding for State highways.

In order to develop an estimate for the cost of completing the system of highways contained in the Master Plan of Highways, it was necessary to identify all needed new roadways, widenings of existing roadways, and reconstruction of existing roads necessary to complete the system. This identification was made during prior work on the General Plan Assessment . It was reviewed for this project to ensure it reflected current master plans and programs. It is included as Appendix 1, which was previously discussed in chapter 2.

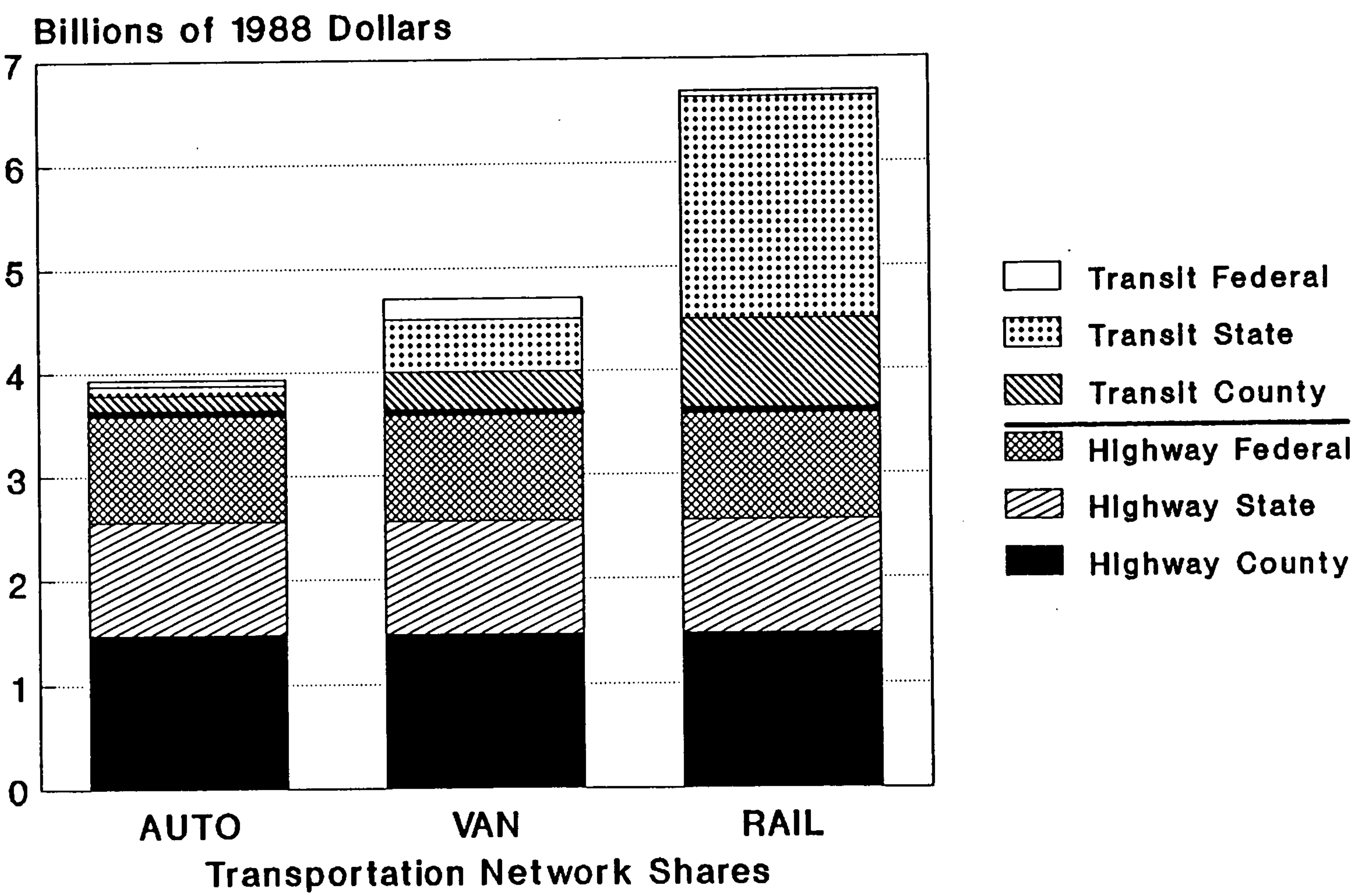
The next step in developing a cost estimate used a highway costing model that was developed under contract for M-NCPPC in 1987. The model consists of matrices of unit costs for bridges, miles of right-of-way, miles of highway lanes, etc. The unit costs are based on 1985 data from the State and County Departments of Transportation, updated to 1988 by indices for inflation in road construction. Design, right-of-way, and length are specified for each roadway section and then multiplied by unit costs.

Initial results from the highway cost model showed unrealistically high right-of-way costs. In order to more accurately predict costs, the proportion of right-of-way costs to construction costs was calculated, by project type, for completed projects. For example, on average, new County roads typically have had a right-of-way cost amounting to 30 percent of the actual construction cost, while for road widenings the average is about 15 percent of construction cost. These proportions were calculated for each roadway type and then used to determine the right-of-way cost for each road segment needed to complete the Master Plan of Highways.

The results of the process described above are summarized in Table 8.1, showing the total cost by County and State funding program category. Table 8.1 also includes the total cost of each of the current FY 89 County CIP and State CTP road programs. These costs are for completion of all projects listed in the CIP and CTP, including costs carried beyond the program period. The costs do not include projects completed in FY 1988. The combination of the programmed roads in the CIP and the CTP and the additional master planned roads constitutes the cost of completing the Master Plan of Highways.

Reconstruction costs for existing State and County roads are included in the operating budgets. In order to maintain the structural integrity of the highway surface and its sub-bases, it is necessary to periodically re-surface the pavement and, less frequently to reconstruct the subbase. Often when there is a widening of a highway,

FIGURE 8.1 **Capital Costs: Transportation Network County, State and Federal Shares**



there is also a reconstruction of the lanes that were there prior to the widening. The reconstruction would be covered in the capital cost of the widening. For that part of the road system maintained by the County an overall program cost of $48 million annually was used for routine and major maintenance costs and the many day-to-day costs to keep the system functioning smoothly. It also includes the department management and administrative costs.

In the State Highway Administration budget all such costs are met out of current receipts, primarily the State gas tax user fees. The State Highway Administration (SHA) generally makes such operating costs the first use of their funding and the remainder goes towards funding new capital construction projects. The SHA also has what they term the Special Projects Program with which they hire contractors to do the more extensive maintenance and repair work. Over the past decade this program has been funded at about $10 million annually. For this fiscal analysis, an annual level of $22 million was used for the maintenance of State highways in the County, including the interstate highways. It covers both the direct costs of the SHA repair crews and the Special Projects Program.

Bus Costs

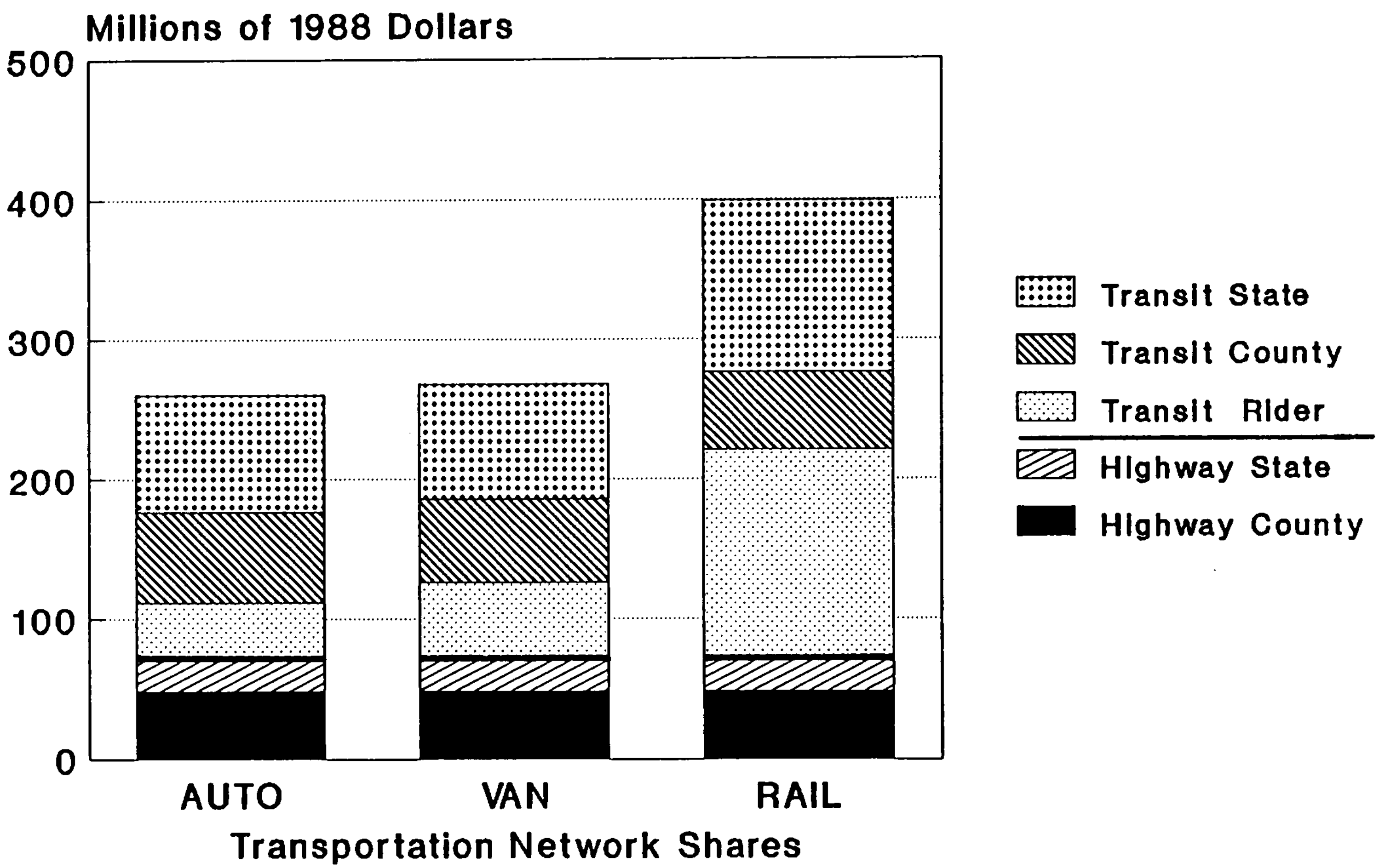
Annual operating costs for buses can be estimated using the average current cost of services in the County of $4.22/per bus mile. As shown in Table 8.2, the annual operating cost for buses in the AUTO scenario would be $147 million, assuming the expansion of service described in Appendix 1. A portion of these costs would be covered by fare revenues. The County's cost would be $103 million, but the State has, in the past, been prepared to support 75 percent of the subsidy requirement.

Capital costs for equipment to cover expansion of the bus system would be $77 million for Ride-On and $55 million for Metrobus, as shown in Table 8.3. This figure assumes Ride-On would provide two-thirds of the added service and Metrobus would provide one-third. It also assumes a replacement factor of 2.5 for buses over the 30 year period. When that is added to the approximately $174 million to replace the existing Ride-on and Metrobus fleets, the total capital costs would be about $306 million.

Metrorail Costs

The current annual Metrorail operating costs to Montgomery County are about $12 million. The change in annual Metrorail operating costs to Montgomery County associated with the Glenmont extension, manning three new stations, and providing shorter headways on the outer sections of the Red Line are estimated at $4 million, bringing the total to $16 million. The Red Line extension north of Wheaton to Glenmont would cost about $175 million to construct. New cars to allow more frequent serviced and to serve the Glenmont extension would cost about $84 million, including their replacement at least once during the 30 year period. It is

FIGURE 8.2 **Operating Costs: Transportation Network Rider, County and State Shares***



*No Federal Share

Table 8.3
BUS CAPITAL COSTS

Transportation Pattern	Number of Existing or Additional Buses	Cost Per Bus	Capital Cost for Initial Purchase ($ millions)	Bus Replacements Over 30 Years	Capital Costs ($ millions) For Additions	Capital Costs ($ millions) With Replacements
Replacement of Existing Fleet						
Ride-On	196	120,000	24	3.0	72	
Metrobus	200	170,000	34	3.0	102	
Total			53		174	
AUTO						
Ride-On	251	120,000	31	2.5	77	149
Metrobus	129	170,000	22	2.5	55	157
Total			53		132	306
VAN						
Ride-On	257	120,000	31	2.5	81	153
Metrobus	135	170,000	23	2.5	58	160
Total			55	139		313
RAIL						
Ride-On	309	120,000	37	2.5	93	165
Metrobus	155	170,000	26	2.5	66	168
Total			63	159		333

also assumed that the existing fleet of Metrorail cars serving Montgomery County would also need to be replaced at least once during the 30 year period at an estimated cost of about $115 million. That would bring the total capital cost for Metrorail to $374 million for the AUTO scenario.

Light Rail Costs

Capital construction and annual operating costs for the Georgetown Branch trolley line between Bethesda and Silver Spring are estimated at $98 million and somewhat less than $3 million, respectively. (DeLeuw Cather/Parsons Brinckerhoff, Spring, 1989, Georgetown Branch Report.)

MARC Costs

Modest improvements in MARC Schedules are already programmed. Equipment costs and operating changes are already in the State's capital program.

Pedestrian and Bicycle Costs

The AUTO scenario assumes an amount equal to 5 percent of the capital cost for highways, or $179 million, will be spent on bicycle baths, bus shelters, and pedestrian improvements over the period 1990-2020.

Section C: Costs For the VAN Scenario

The development of cost estimates for HOV facilities has relatively little history in comparison to estimating procedures for highway and transit systems. For that reason we have shown in somewhat greater detail the various steps that were followed to produce the HOV capital and operating cost estimates.

HOV Facility Costs

Costs of HOV facilities were developed using the "Table Of Assumed HOV Treatments By Road Links" in Appendix 2. This Appendix contains diagrams of each treatment. Cost information was developed from available data or other similar construction projects, taking into account the operational and enforcement requirement of each HOV facility. Cost items and their assumptions are listed below. All costs are capital costs except annual enforcement cost. Their development is detailed in Table 8.4. Terms used in Table 8.4 are explained below:

Construction cost: This represents the incremental costs needed to provide the HOV lanes and ramps over the base unrestricted facility. For example, adding a center reversible lane for HOVs requires construction in the median. No construction is needed for reallocating unrestricted lanes to HOV lanes. Right-of-way (ROW) acquisition costs are not included in the construction cost. Construction costs were developed for two roadway types: controlled highways (I-495, I-270, I-370, ICC, and

Table 8.4
COMPREHENSIVE GROWTH POLICY STUDY
MONTGOMERY COUNTY

COST ESTIMATE FOR HOV TREATMENTS
(6/13/89)

Routes	Project Limits: Between	Project Limits: And	Length miles	MPH	Project Type	HOV Treatment	Cost ($1000/mile): Constru.	Cost ($1000/mile): Systems	Cost ($1000/mile): Enforce.	Segment Cost ($1000): Constru.	Segment Cost ($1000): Systems	Segment Cost ($1000): Enforce.	R.O.W ($1000)	Ramp Metering
RT.27	Howard C.L.	S. of Damascus	8.6	2/2	Add C. Ln.	2/1R/2	1320	75	5	11,352	645	43	4,087	
	S. of Damascus	I-270	2.6	3/3	Recons. C Ln	2/1R/2	1848	75	5	4,805	195	13		
Midcounty Hwy	MD 27	ICC	8.3	3/3	Recons. C Ln	2/1R/2	1848	75	5	15,338	623	42		
Great Seneca Hwy	I-270	Ritchie Pkwy	10.1	3/3	Recons. C Ln	2/1R/2	1848	75	5	18,665	758	51		
Ritchie Pkwy	Great Seneca	MD 28	4.9	2/2	Add C. Ln.	2/1R/2	1320	75	5	6,468	368	25	2,328	
Shady Grove Rd	Great Seneca	Midcounty Hwy	4.2	3/3	Convert 2 Ln	1+2/1+2	0	125	7.5	0	525	32		
Gude Dr.	Shady Grove Rd	MD 355	2.2	3/3	Recons. C Ln	2/1R/2	1848	75	5	4,066	165	11		
	MD 355	MD 28	2.1	2/2	Convert 2 Ln	1+1/1+1	0	125	7.5	0	263	16		
MD 28	MD 355	MD 97	4.1	2/2+ service	Add 2 Ln & Convert 2 Ln	1+2/1+2	1584	125	7.5	6,494	513	31	2,598	
MD 97	Olney	Randolph Rd.	7.3	3/3	Add C. Ln.	3/1R/3	1320	75	5	9,636	548	37	3,469	
Connecticut Ave	MD 97	DC Line	8.3	3/3	Convert 2 Ln	1+2/1+2	0	125	7.5	0	1,038	62		
Old Georgetown	MD 355	NIH	3.7	3/3	Convert 2 Ln	1+2/1+2	0	125	7.5	0	463	28		
	NIH	Wisconsin Ave.	1.5	2/1/2	Convert 2 Ln	1+1/1/1+1	0	125	7.5	0	188	11		
River Rd.	Falls Rd.	Westbard	7.1	3/3	Recons. C Ln	2/1R/2	1848	75	5	13,121	533	36		
G.W. Mem. Pkwy	I-495	DC Line	4.8	2/1	Convert 2 Ln	1+1/1	0	150	7.5	0	720	36		
Cabin John Pkwy	I-495	G.W. Mem. Pkwy	1.2	2/2	Convert 2 Ln	1+1/2	0	150	7.5	0	180	9		
US 29	County Line	MD 650	7.6	3/3	Add C. Ln.	3/1R/3	1320	75	5	10,032	570	38	3,612	
	MD 650	Silver Spring	4.4	3/1/3 (rev.4/2)	Convert 3 Ln	1+2/1/1+2	0	200	10	0	880	44		
I-270	County Line	MD 121	4.1	3/3	Add 2 C. Ln	3/2R/3	2112	100	10	8,659	410	41	2,598	
	MD 121	MD 124	7.0	4/4	Add 2 C. Ln	4/2R/4	2112	100	10	14,784	700	70	4,435	
	MD 124	MD 117	0.5	4/4/2	Add 2 C. Ln	4/2R/4/2	2112	100	10	1,056	50	5	317	
	MD 117	Spurs	8.3	2/4/4/2	Convert 4 Ln	2/2+2/2+2/2	0	150	10	0	1,245	83		
	West Spur		1.7	3/3	Add 2 Ln & Convert 2 Ln	2+2/2+2	2376	200	10	4,039	340	17	1,616	
	East Spur		2.6	3/3	Convert 2 Ln	2+1/2+1	0	125	7.5	0	325	20		
	9 Interchanges Option-A									106,680	900	45		

continued

Routes	Project Limits Between	And	Length miles	MPH	Project Type	HOV Treatment	Cost ($1000/mile) Constru.	Systems	Enforce.	Segment Cost ($1000) Constru.	Systems	Enforce.	R.O.W ($1000)	Ramp Metering
I-370	I-270	ICC	2.1	3/3	Convert 2 Ln	2+1/2+1	0	125	7.5	0	263	16		
ICC	I-370	Rockville Fac.	8.4	3/3	Add 2 C Ln & Reduce 2 Ln	2/2R/1+1	2957	200	10	24,839	1,680	84		
	Rockville Fac.	County Line	5.4	4/4	Add 2 C. Ln & Reduce 2 Ln	3/2R/2+1	2957	200	10	15,968	1,080	54		
	3 Interchanges Option-A									19,650	300	15		
I-495	County Line	US 29	2.5	4/4	Add 2L + 2 Sh	2+4/2+4	2376	200	10	5,940	500	25	2,376	
	US 29	MD 355/E. Spur	5.0	4/4	Conv 2L + 2 Sh	2+3/2+3	0	200	10	0	1,000	50		
	E. Spur	W. Spur	2.6	3/3	Add 2 Ln	3+1/3+1	2376	150	7.5	6,178	390	20	1,647	
	W. Spur	River Rd.	1.5	5/5	Add 2 Ln & Convert 2 Ln	2+4/2+4	2376	200	10	3,564	300	15	1,426	
	River Rd.	Potomac River	2.3	4/4	Add 2 Ln & Convert 2 Ln	3+2/3+2	2376	200	10	5,465	460	23	2,186	
	7 Interchanges Option-A									106,680	700	35		
Rockville Fac.	ICC	MD 97	2.3	1/1	Convert 2 Ln	2HOV/-	0	100	5	0	230	12		
	MD 97	Veirs Mill Rd	1.7	0	Construct 2 Ln	2HOV/-	2904	200	5	4,937	340	9	2,154	
	Veirs Mill Rd	MD 355	1.5	2/2	Reduction	2HOV/-	1584	100	7.5	2,376	150	11		
	MD 355	I-270	2.1	2/2	Convert 4 Ln	2HOV/2HOV	0	100	10	0	210	21		
	I-270	MD 189	1.4	1/1	Add C. Ln & Convert 2 Ln	1/1/1R	1700	150	10	2,380	210	14	665	
New Hampshire	US 29	County Line	2.8	3/3	Convert 2 Ln	2+1/2+1	0	125	7.5	0	350	21		
Column Total + 25% contingency ($1,000)										541,464	26,628	1,582	44,392	0

Total Capital Cost: 612,483
Annual Enforce. Cost: 1,582

NOTE: 1. R.O.W cost $3/sq.ft.
2. Ramp metering cost $50,000 each.
3. Total Capital Cost does not include "Enforcement Cost".

Rockville Facility) and arterials (Georgia Avenue, Connecticut Avenue, etc.)

Systems cost: This includes the costs for signs, marking, and control needs such as gates. Unit cost is between $75,000 and $200,000 per mile depending on the cross section. A cross section with more HOV lanes has a higher unit systems cost. Ramp metering is treated as a separate item from the systems cost.

Ramp metering: Where no HOV exclusive ramps are built, isolated ramp metering devices are installed for HOVs to bypass LOVs at interchange ramps. A unit cost of $50,000 each was assumed.

Enforcement cost: This reflects the incremental costs of police services for HOV lanes or separate HOV facilities. Most HOV facilities operate only during peak periods of approximately three hours in the morning and in the evening. Police assigned to HOV patrolling normally will cover other roads as well and, therefore, only a portion of their daily costs can be allocated to HOV enforcement. HOV enforcement is also not necessary every day. HOV enforcement has been found to be most cost-effective when it is done on a saturation basis for several days to get the violation rates within an acceptable level and then performed periodically to maintain an acceptable level. If violation rates increase significantly, then saturation enforcement would be repeated. The cost estimates assume that enforcement personnel are not fully allocable to HOV enforcement, but share their time on a variety of enforcement functions.

ROW cost: To acquire additional land for HOV lanes, a unit cost of $3/sq. ft is assumed. It is meant to cover the cost of ROW for additional lanes either in the median or on both sides unless, there is a lane reduction to compensate.

Reversible vs. two-way: Two-way HOV physically separate facilities require twice as many exclusive ramps as center-reversible HOV facilities.

Ramp costs: Freeway HOV facilities require special treatments for HOVs to enter and exit the facility at the interchanges, as well as from the mainline. It has been assumed that each interchange on freeways has ramp meter bypass for HOVs where the HOV facility is not physically separate. Where the HOV facility is physically separate there would be exclusive HOV ramps at every interchange.

Construction costs for exclusive ramps were based on available data from other bridge construction costs taking into account structure modification. Each exclusive ramp was assumed to be 100 feet long, 30 feet wide, and cost $127 per sq. ft., which results in a cost of $3,810,000 per ramp.

Slip ramp costs: Each slip ramp was assumed to be 1,400 feet long and cost $300 per foot, which results in a per-ramp cost of $420,000. Each ramp bypass was assumed to be 2,000 feet long and $300 per foot, which results in a cost of $60,000 per ramp.

Ramp metering costs: Systems costs for interchanges were assumed to be $100,000 each. Enforcement costs were assumed to be $5,000 per interchange annually.

The final total cost includes a 25 percent contingency to adjust for other related costs such as planning, design, and utilities.

Non-HOV Highway Costs

The non-HOV highway costs are the same as in the AUTO scenario.

Bus Costs

The bus capital costs are estimated at $31.3 million, as shown in the above discussion on the AUTO scenario. They do not include the cost of building priority busways. Bus operating costs are $154 million, reflecting a 5 percent increase over the AUTO scenario.

Metrorail Costs

The Metrorail costs are the same as in the AUTO scenario.

MARC Costs

The MARC costs are the same as in the AUTO scenario.

Light Rail Costs

Light rail costs are the same as in the AUTO scenario.

Pedestrian and Bicycle Costs

These costs are assumed to be $358 million, which represents 10 percent of the capital cost for highways.

Section D: Costs for the RAIL Pattern

Highway Costs

The highway capital and operating costs for the RAIL scenario will be the same as they are in the AUTO scenario.

Metrorail Costs

Metrorail service would be expanded compared to the AUTO scenario. The capital costs increase from $374 million to $408 million and the operating costs from $16 million to $19 million.

Light Rail Costs

The light rail network of five lines, with a total length of about 67 miles, would cost $2.4 billion to construct. Table 8.5 shows the build-up of capital costs by major system item. With the assumed schedules, average wait time at stations would be three minutes in the peak period. Table 8.6 shows these costs in more detail, with explanatory notes.

Table 8.5
LIGHT RAIL CAPITAL COSTS
(in millions of dollars)

Item	Cost/Unit	Units	Cost
Track			
At-Grade	6.5	40.1	261
Viaduct	24.0	9.5	227
Tunnel	45.0	1.9	85
Open Cut/Fill	10.0	12.0	120
Structures			
Major Crossing	2.2	39.0	86
At-Grade	0.3	17.0	5
Power	0.9	63.4	55
Stations			
Local	0.2	34.0	6
Express	5.0	25.0	125
Terminal	12.0	5.0	60
Vehicles	1.7	206.0	350
Vehicle Replacement	1.7	206.0	350
Right-of-Way	0.5	63.4	32
Yard	20.5	3.0	62
Storage	7.5	3.0	23
Parking	0.0	17000	68
Subtotal			1914
Contingency	0.25		479
TOTAL COST			2393

Table 8.6
MONTGOMERY COUNTY GROWTH POLICY STUDY
CAPITAL COST ESTIMATE
RAIL STRATEGY

LIGHT RAIL CAPITAL COSTS					*COST DETAILS BY LINE SEGMENT*								
ITEM Track		Unit Cost$m	Units mi or #	Cost($m)	By Line BurSS	(feet) SSBeth	BethRR	RRMM	MMTBk	TbkSG	TbkPG	SGCkbg	
	Atgrade	6.5	40.1	261	47000	23000	0			11700	50000	80000	
	Viaduct	24.0	9.5	227				8000	12000	20000	10000	0	
	—	0.0	0.0	0			0						
	Tunnel	45.0	1.9	85	5000		0				5000	0	
	Cut/Fill	10.0	12.0	120				32700	8000	10000	12600	0	
Sub-Total			63.4		100	28		98	70	124	173	98	
Structures													
	Major Xg	2.20	39	86	7	3		4	1	1	10	13	
	AtGrade	0.27	17	5	5	2		0	2		2	6	
Sub-Total					17	7		9	3	2	23	30	
PowerEtc		0.87	63.4	55	9	4		7	3	7	13	13	55
Stations													
	local	0.18	34	6	8	3		2	2	5	6	8	
	express	5.00	25	125	3	2		1	3	3	4	9	
	terminal	12.00	5	60	1	1		1			1	1	
Sub-Total					28	23		17	15	16	33	58	
Vehicles		1.7	206	350									
Veh. Replacement		1.7	206	350									
Sub-Total					109	48		85	42	87	162	167	700
ROW		0.5	63.4	32	5	2	0	4	2	4	7	8	
Yard		20.5	3	61.5	20.5						20.5	20.5	
StorFac		7.5	3	22.5	7.5						7.5	7.5	
Parking		0.004	17000	68	11	5	0	8	4	8	16	16	68
Sub-Total				1914	306	117	0	228	139	249	455	419	1914
Contingency (25%)				478	77	29	0	57	35	62	114	105	
TOTAL COST				2392	383	146	0	285	174	311	569	524	2392

Notes for Table 8.6

A simple estimation procedure was used to estimate operating costs for the LRT (light rail transit) network. Existing LRT system operating cost histories were reviewed to determine the significant cost variables.

Operating cost histories for existing light rail systems exhibit a substantial amount of variability nationally. Among this group of LRT operators there are a number of efficient authorities who are running new systems in a cost-effective fashion. They rely upon self-service fare collection, one-man train operation, flexible staff assignments and outside contracting for services wherever it is less costly. The estimated operating costs for the proposed Georgetown Branch trolley line are based upon this type of efficient operation, and the estimates here are based on the work done for the Georgetown Branch. The operating cost estimates that vary with specific operating characteristics of the LRT are under consideration. Operating characteristics and the cost variables associated with them are listed below:

1. Route length in miles for cost of management, administration, track, power, signal main.
2. Number of light rail vehicles operated in the peak period, for cost of daily car inspection and servicing.
3. Train hours operated annually, for drivers' wages.
4. Car miles operated annually, for cost of power, and vehicle maintenance

During the work on Georgetown Branch, very detailed estimates were developed of the costs associated with each of these operating characteristics. Those costs are as follows:

Route Length (miles) X $176,000

Peak Vehicles (#) X $24,000

Train Hours (000's/yr) X $22,130

Cars Miles (000's/yr) X $2,500

Some other adjustments were also made. As the Georgetown Branch trolley estimates assumed that County Ride-On would administer the system and stations would be unmanned, it was necessary to adjust operating costs slightly. Accordingly, it was assumed that administration would be 20 percent of basic operating costs and that station personnel costs would total $256,000 for each express station on the system. Local stations would not be manned. An overhead factor of 75 percent of base wages was used. Wage rates are based upon current WMATA rates multiplied by 0.75. This reflects existing differentials between Ride-On and Metrorail for staff undertaking equivalent duties.

At this level of service the annual operating cost would be $108 million per year, as indicated in Table 8.7. Table 8.8 summarizes capital and operating costs by major segment of the light rail system.

Most of the routes would use surface rights-of-way along major highways that have enough width to ac-

Table 8.7
RAIL STRATEGY
LIGHT RAIL OPERATING COSTS PER YEAR

Element	Miles	Vehicles	TrainHrs	VehMiles	TOTAL
Unit Cost Factor ($1000 per unit) Line Segment	176.00	24	22.13	2.5	
Burt-SS	9.8	27	46.8	2920	11
SS-Beth	4.4	16	31.9	1990	7
Beth-RR	0.0	0	0.0	0	
RR-NVABr	2.7	3	2.9	116	1
RR-TwBk	11.5	36	54.7	4710	16
TwBK-SG	7.9	36	54.7	3460	12
TwBk-Whtn	2.6	6	10.3	804	3
Whtn-PG	12.1	28	47.9	3739	13
SG-Ckbg	11.7	36	55.0	4800	16
Ckbg-CoLine	3.4	11	16.0	1395	5
Sub-Total	66.0	198	320.2	23934	
Cost Extension	11623.0	4762	7085.9	59834	83
Administration (20% X 83)					17
Express Station Operation (30 stations at $256K/station)					8
TOTAL LRT OPERATING COSTS					108

Table 8.8
RAIL STRATEGY
LIGHT RAIL TRANSIT LINE SUMMARY

Capital and Operating Costs

Route	Length (miles)	Capital Costs ($million)	Operating Costs ($million/year)
Burtonsville-Bethesda	14.2	529	23
North VA-Twinbrook	14.2	459	22
Twinbrook-Prince George's	14.7	569	21
Twinbrook-Shady Grove	7.9	311	15
Shady Grove-Clarksburg	15.1	524	27
Sub-Total	66.1	2392	108

Note: LRT Route to Clarksburg extends to County Line
Capital and operating costs were individually estimated by line segment.

commodate the LRT tracks with stations at most major intersections. Due to the schedules planned, all lines would have double tracks. Grade separation has been assumed for all crossings of major highways. At-grade crossings with traffic controls are assumed at minor highway junctions. The network contains 64 stations, of which 25 would be express/transfer stations.

Priority Bus Costs

As shown in Appendix 1, two busways are proposed that would cost $56 million to construct, based upon the schedule of costs shown in Table 8.9. Operating costs for the bus routes that would use the priority lanes are covered within the costing of the bus network operations in Table 8.2.

Conventional Bus Costs

Overall bus service, including routes on the priority system, was increased by 20 percent over the AUTO scenario to serve the busway and regular transit network, for a total of $178 million in annual operating costs as shown in Table 8.2. Capital costs of equipment and garage facilities are estimated at $333 million, as shown in Table 8.3, which includes replacements of the existing fleets.

MARC Costs

The MARC system would be further upgraded from minimum headways of 15 minutes to provide 10-minute peak period headways using new commuter equipment. The added capital cost to upgrade MARC stations and upgrade service will be $40 million, and the added operating cost will be $14 million. These costs are developed in Table 8.10. Capital and operating costs would be covered by the State.

Pedestrian and Bicycle Costs

The RAIL scenario assumes that $537, an amount equal to 15 percent of the capital budget for roads, will be spent between 1990-2020 to produce a much safer and pedestrian- and bicycle-friendly environment.

Section E: State and Federal Funding

Table 8.11 summarizes capital and operating costs for the three strategies. Tables 8.12, 8.13, and 8.14 show the share of operating and capital costs that will be funded by the County, the State government, and the federal government under better- and worse-case assumptions.

The expected levels of grants for future transportation needs are difficult to estimate. It seems safe to make several assumptions, however. First, given the high profile of traffic congestion as an issue in the State and across the nation, it seems unlikely that the total dollar amounts appropriated for transportation by the State and federal governments will decline dramatically, at least until the problem has been effectively addressed. Second, funding levels for different types of transportation systems are likely to vary regardless of whether the overall funding level changes. The pressure to develop

Table 8.9
RAIL STRATEGY
BUS PRIORITY SYSTEM CAPITAL COSTS

Project	Length (in miles)	Unit (in millions)	Cost (in millions)
ICC (Route 29 to County Line)	2.0	$4.3	$8.6
Georgia Avenue (Olney To Glenmont)	4.8	$4.3	$20.6
Total	6.8	$8.6	$29.2
Systems & Structures (50% of base cost)			$14.6
Contingency (25% of total cost)			$11.0
TOTAL Bus Priority System			$54.8

*based upon facility type and ROW requirements, using MPH unit costs

Table 8.10
RAIL STRATEGY
MARC RAIL COSTS

		Miles per year (in millions)	Cost/MMY (in millions)	Cost (in millions)
Capital Cost				
Trains	6		6.0	36
Stations	8		0.5	4
				40
Additional Operating Costs		84	167	$14

Table 8.11
SUMMARY OF CAPITAL AND OPERATING COSTS BY PATTERNS AND SYSTEM

CAPITAL COSTS BY PATTERN (millions of dollars)

Transportation System	AUTO	VAN	RAIL
Pedestrian/Bikeways	179	358	537
Highways	3,582	3,582	3,582
Buses	306	313	333
Priority Busways	—	—	56
Light Rail	98	98	2,392
Metrorail	374	374	408
MARC	0	0	40
HOV	—	613	—
TOTAL	4,539	5,338	7,348

OPERATING COSTS BY STRATEGY (millions of dollars per year)

Transportation System	AUTO	VAN	RAIL
Pedestrian/Bikeways	3	7	11
Highways	70	70	70
Buses	147	154	178
Priority Busways	—	—	—
Light Rail	3	3	108
Metrorail	16	16	19
MARC	0	0	14
HOV	—	2	—
TOTAL	239	252	400

Table 8.12
CAPITAL AND OPERATING INTERGOVERMENTAL COST SHARES FOR THE AUTO PATTERN

CAPITAL COSTS (in Millions)

AUTO PATTERN Transportation Network Components update 7-06-89		Estimated Capital Costs	BETTER CASE						WORSE CASE					
			Percent Share of Costs:			Estimated Costs To:			Percent Share of Costs:			Estimated Costs To:		
			County	State	Federal	County	State	Federal	County	State	Federal	County	State	Federal
RAIL	MARC	0	0	25	75	0	0	0	50	25	25	0	0	0
	Metro	374	0	30	70	0	112	262	50	30	20	187	112	75
	LRT	98	0	30	70	0	29	69	50	30	20	49	29	20
BUS	Busways	0	0	50	50	0	0	0	50	30	20	0	0	0
	Metrobus	157	0	20	80	0	31	126	50	50	0	79	79	0
	Ride-On	149	25	75	0	37	112	0	62	38	0	92	57	0
Highways	Federal	560	0	10	90	0	56	504	50	25	25	280	140	140
	State	2062	0	70	30	0	1443	619	50	50	0	1031	1031	0
	County	960	100	0	0	960	0	0	100	0	0	960	0	0
	Non-road*	179	80	10	10	143	18	18	90	10	0	161	18	0
	HOV Lanes	0	0	30	70	0	0	0	50	30	20	0	0	0
TOTALS		4539				1140	1802	1597				2839	1466	234

OPERATING COSTS (in millions)

AUTO PATTERN Transportation Network Components update 7-06-89		Estimated Operating Costs	Operating Subsidy Percent	BETTER CASE							WORSE CASE						
				Percent Share of Costs:			Estimated Costs To:				Percent Share of Costs:			Estimated Costs To:			
				County	State	Federal	Riders	County	State	Federal	County	State	Federal	Riders	County	State	Federal
RAIL	MARC	0	45	0	100	0	0	0	0	0	50	50	0	0	0	0	0
	Metro	16	25	15	75	10	12	1	3	0	57	43	0	12	2	2	0
	LRT	3	0	15	75	10	3	0	0	0	57	43	0	3		0	0
BUS	Busways	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metrobus	49	65	15	75	10	17	5	24	3	57	43	0	17	18	14	0
	Ride-On	98	75	25	75	0	25	18	55	0	62	38	0	25	46	28	0
Highways	Federal	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	State	22	100	0	100	0	0	0	22	0	50	50	0	0	11	11	0
	County	48	100	80	10	10	0	38	5	5	90	5	5	0	43	2	2
	Non-road*	3	100	80	10	10	0	2	0	0	90	5	5	0	3	0	0
	HOV Lanes	0	100	25	75	0	0	0	0	0	62	38	0	0	0	0	0
TOTALS		239					57	65	109	9				57	123	57	3

Table 8.13
CAPITAL AND OPERATING INTERGOVERNMENTAL COST SHARES FOR THE VAN PATTERN

CAPITAL COSTS (in millions)

VAN PATTERN Transportation Network Components update 7-06-89		Estimated Capital Costs	BETTER CASE Percent Share of Costs: County	State	Federal	Estimated Costs To: County	State	Federal	WORSE CASE Percent Share of Costs: County	State	Federal	Estimated Costs To: County	State	Federal
RAIL	MARC	0	0	25	75	0	0	0	50	25	25	0	0	0
	Metro	374	0	30	70	0	112	262	50	30	20	187	112	75
	LRT	98	0	30	70	0	29	69	50	30	20	49	29	20
BUS	Busways	0	0	50	50	0	0	0	50	30	20	0	0	0
	Metrobus	160	0	20	80	0	32	128	50	50	0	80	80	0
	Ride-On	153	25	75	0	38	115	0	62	38	0	95	58	0
Highways	Federal	560	0	10	90	0	56	504	50	25	25	280	140	140
	State	2062	0	70	30	0	1443	619	50	50	0	1031	1031	0
	County	960	100	0	0	960	0	0	100	0	0	960	0	0
	Non-road*	358	60	30	10	215	107	36	90	10	0	322	36	0
	HOV Lanes	613	0	30	70	0	184	429	50	30	20	307	184	123
TOTALS		5338				1213	2079	2046				3311	1670	357

OPERATING COSTS (in millions)

VAN PATTERN Transportation Network Components update 7-06-89		Estimated Operating Costs	Operating Subsidy Percent	BETTER CASE Percent Share of Costs: County	State	Federal	Estimated Costs To: Riders	County	State	Federal	WORSE CASE Percent Share of Costs: County	State	Federal	Estimated Costs To: Riders	County	State	Federal
RAIL	MARC	0	40	0	100	0	0	0	0	0	50	50	0	0	0	0	0
	Metro	16	20	15	75	10	13	0	2	0	57	43	0	13	2	1	0
	LRT	3	0	15	75	10	3	0	0	0	57	43	0	3	0	0	0
BUS	Busways	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metrobus	51	50	15	75	10	26	4	19	3	57	43	0	26	15	11	0
	Ride-On	103	70	25	75	0	31	18	54	0	62	38	0	31	45	2	0
Highways	Federal	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	State	22	100	0	100	0	0	0	22	0	50	50	0	0	11	11	0
	County	48	100	80	10	10	0	38	5	5	90	5	5	0	43	2	2
	Non-road*	7	100	80	10	10	0	6	1	1	90	5	5	0	6	0	0
	HOV Lanes	2	100	25	75	0	0	1	2	0	62	38	0	0	1	1	0
TOTALS		252					72	67	105	8				72	123	54	3

Table 8.14
CAPITAL AND OPERATING INTERGOVERNMENTAL COST SHARES FOR THE RAIL PATTERN

CAPITAL COSTS (in millions)

RAIL PATTERN Transportation Network Components update 7-06-89		Estimated Capital Costs	BETTER CASE: Percent Share of Costs: County	State	Federal	BETTER CASE: Estimated Costs To: County	State	Federal	WORSE CASE: Percent Share of Costs: County	State	Federal	WORSE CASE: Estimated Costs To: County	State	Federal
RAIL	MARC	40	0	25	75	0	10	30	50	25	25	20	10	10
	Metro	408	0	30	70	0	122	286	50	30	20	204	122	82
	LRT	2392	0	30	70	0	718	1674	50	30	20	1196	718	478
BUS	Busways	56	0	50	50	0	28	28	50	30	20	28	17	11
	Metrobus	168	0	20	80	0	34	134	50	50	0	84	84	0
	Ride-On	165	25	75	0	41	124	0	62	38	0	102	63	0
Highways	Federal	560	0	10	90	0	56	504	50	25	25	280	140	140
	State	2062	0	70	30	0	1443	619	50	50	0	1031	1031	0
	County	960	100	0	0	960	0	0	100	0	0	960	0	0
	Non-road*	537	45	45	10	242	242	54	90	10	0	483	54	0
	HOV Lanes	0	0	30	70	0	0	0	50	30	20	0	0	0
TOTALS		7348				1243	2776	3329				4389	2238	721

OPERATING COSTS (in millions)

RAIL PATTERN Transportation Network Components update 7-06-89		Estimated Operating Costs	Operating Subsidy Percent	BETTER CASE: Percent Share of Costs: County	State	Federal	BETTER CASE: Estimated Costs To: Riders	County	State	Federal	WORSE CASE: Percent Share of Costs: County	State	Federal	WORSE CASE: Estimated Costs To: Riders	County	State	Federal
RAIL	MARC	14	25	0	100	0	11	0	4	0	50	50	0	11	2	2	0
	Metro	19	15	15	75	10	16	0	2	0	57	43	0	16	2	1	0
	LRT	108	30	15	75	10	76	5	24	3	57	43	0	76	18	14	0
BUS	Busways	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Metrobus	59	55	15	75	10	27	5	24	3	57	43	0	27	18	14	0
	Ride-On	119	55	25	75	0	54	16	49	0	62	38	0	54	41	25	0
Highways	Federal	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	State	22	100	0	100	0	0	0	22	0	50	50	0	0	11	11	0
	County	48	100	80	10	10	0	38	5	5	90	5	5	0	43	2	2
	Non-road*	11	100	80	10	10	0	9	1	1	90	5	5	0	10	1	1
	HOV Lanes	0	100	25	75	0	0	0	0	0	62	38	0	0	0	0	0
TOTALS		400					182	74	131	13				182	145	70	3

new and better means of addressing congestion will mean ongoing shifts in the amounts the State and Federal governments put into different transportation systems. Finally, some State and federal transportation funding is discretionary and not based on a per capita or other formula, which makes it difficult to accurately estimate how much the County is likely to receive.

The U.S. Department of Transportation and numerous transportation organizations have been conducting ongoing studies as part of a program called Transportation 2020, to identify national transportation needs. Recent estimates from the program indicate that future capital and operating requirements by all levels of government nationally will require about $90-120 billion dollars a year, in contrast to the $75 billion currently being spent.

Two alternative future directions for federal and State transportation funding can be envisioned, which are called the "Sunny Prospect" and the "Stormy Prospect."

The Sunny Prospect would be consistent with the increased spending the Transportation 2020 program feels is necessary. It would also be consistent with the recent initiatives by the State government to fund a significant portion of the proposed Georgetown Branch trolley, and with the State's general leadership nationally in transportation planning. Maryland is the only state in the country with a Consolidated Transportation Program for financing of transportation improvements.

The Stormy Prospect is likely to occur if the inability of U.S. companies to compete internationally results in lower incomes, and therefore lower tax revenues. For this alternative, this Study assumes that the present State and Federal shares of total transportation funding for the County are reduced by one-half in each case. Due to the fact that State and Federal levels for some categories, such as transit, are higher than others, a cutback in every category by half results, in the Stormy Prospect, in County shares that are two times higher than the Sunny Prospect for the AUTO, two and a half times higher for the VAN, and three times higher for the RAIL scenario.

Chapter 9

Cost Estimates for Water and Sewer

CHAPTER 9: COST ESTIMATES FOR WATER AND SEWER

The Comprehensive Growth Policy Study has focused primarily on traffic congestion and fiscal impacts. The land use scenarios and the transportation networks also have significant implications for environmental costs. These have not been thoroughly quantified due to lack of time and resources, and the fact that these costs are met mostly through user fees and through unquantified changes in the quality of life. They do not directly affect the fiscal analysis undertaken by this Study. The fact that they are dealt with less thoroughly in this report is not a reflection of any lesser importance.

Section A: Water Supply

Great effort has gone into water supply planning for the Washington metropolitan area. This region, which consists of the District of Columbia, and the adjacent counties of Maryland and Virginia, encompasses an area of approximately 3,000 square miles. The region is dependent on the Potomac River as its major water supply source. At present the daily flow of the Potomac is subject to extreme variation, with the average discharge of the Potomac at Washington, D.C. being about 7 billion gallons per day (bgd). However, in 1986, the Potomac flow dropped to a low of 388 mgd, which is almost equal to or less than metropolitan area demand.

Potable water for the metropolitan area is supplied by three major systems managed by: The Washington Suburban Sanitary Commission (WSSC), Fairfax County Water Authority (FCWA), and the Washington Aqueduct Division of the U.S. Army Corps of Engineers (WAD).

The total storage capacity in each system generally amounts to only one day's supply. (See Table 9.1) . These systems are interconnected to a small degree. There exists an urgent need to improve the existing water supply system both in terms of quality and reliability.

The above is an oversimplified summary of the water supply problem from a regional perspective. However, the focus of this discussion will be on water supply for the Montgomery County area. The Washington Suburban Sanitary Commission (WSSC) is responsible for operating and maintaining the water supply for the Maryland side of the Washington metropolitan area. WSSC utilizes two sources of raw water, the Patuxent River and the Potomac River. The Patuxent River flow is regulated by two reservoirs, Triadelphia and Howard Duckett.

These facilities have combined storage at normal water levels. The maximum sustained WSSC Patuxent River withdrawal during the 100 year drought would be between 32 mgd and 42 mgd. (WSSC has a generally accepted safe yield of 42 mgd during 100-year drought, and a required flow-by up to 10 mgd.) The Patuxent

Table 9.1

BASIC FACTS ON THE THREE WATER SYSTEMS

ITEMS	WSSC	FCWA	WAD
a. Area Served	Montgomery & Prince George's Counties	Fairfax County	Wash., D.C.; Arlington,Va.; Falls Church, Va.; National Airport; Pentagon; Andrews AFB
b. # of People Served	1.2 Million	0.5 Mil.	1.2 Million
c. Source of Raw Water	75% Potomac 25% Patuxent	40% Occoquan 60% Potomac	100% Potomac
d. Raw Water Storage Capacity	Excellent 100 Day (Patuxent)	Excellent over 100 days	None
e. Finished Water Storage	None	None	Less than one day supply

water treatment plant (WTP) is the only facility that can utilize the Patuxent River as a source of raw water.

The Potomac River is a shared resource; the maximum WSSC withdrawal during low flow conditions is restricted by the terms of the Potomac Low Flow Allocation Agreement. The allowable WSSC withdrawal is generally estimated to be 30 to 40 percent of the available Potomac flow. The WSSC Potomac WTP is currently the only facility which can utilize Potomac water to supply the WSSC distribution system. The WTP has intake facilities for 400 mgd and a treatment capacity of 300 mgd.

The natural Potomac flow is to be increased during low flow conditions by two recently completed reservoirs: (1) the Randolph Dam (formerly the Bloomington Dam), which is owned and operated by the Army Corps of Engineers and contains 13 billion gallons of usable storage contracted for and can be shared by WAD, FCWA, and the WSSC; and (2) the Little Seneca reservoir, which is a WSSC owned and operated reservoir in Montgomery County that contains 4 billion gallons of usable emergency storage that can also be shared by the three public water supply systems for the metropolitan area. The Little Seneca reservoir increases operational flexibility and reliability because released storage reaches the WSSC Potomac WTP in 16 hours as compared to 7 days for releases from the Randolph dam.

In conjunction with local agencies, COG and the Corps of Engineers, the Interstate Commission on the Potomac River Basin developed a model that simulates Potomac flow and helps local jurisdictions coordinate withdrawal from the Potomac during low flow. With this information, other research, and future need projections done by WSSC, the WSSC concludes that the raw water supply of WSSC will be adequate through the year 2030 under the 100 year drought condition. The adequate supply provided by the WSSC is contingent on future consumption projections, continued scheduled and unscheduled maintenance, and the availability of information sources (e.g. computer technology geared toward the handling of water systems operational data). A summary of some of these needs is shown in Figure 9.1.

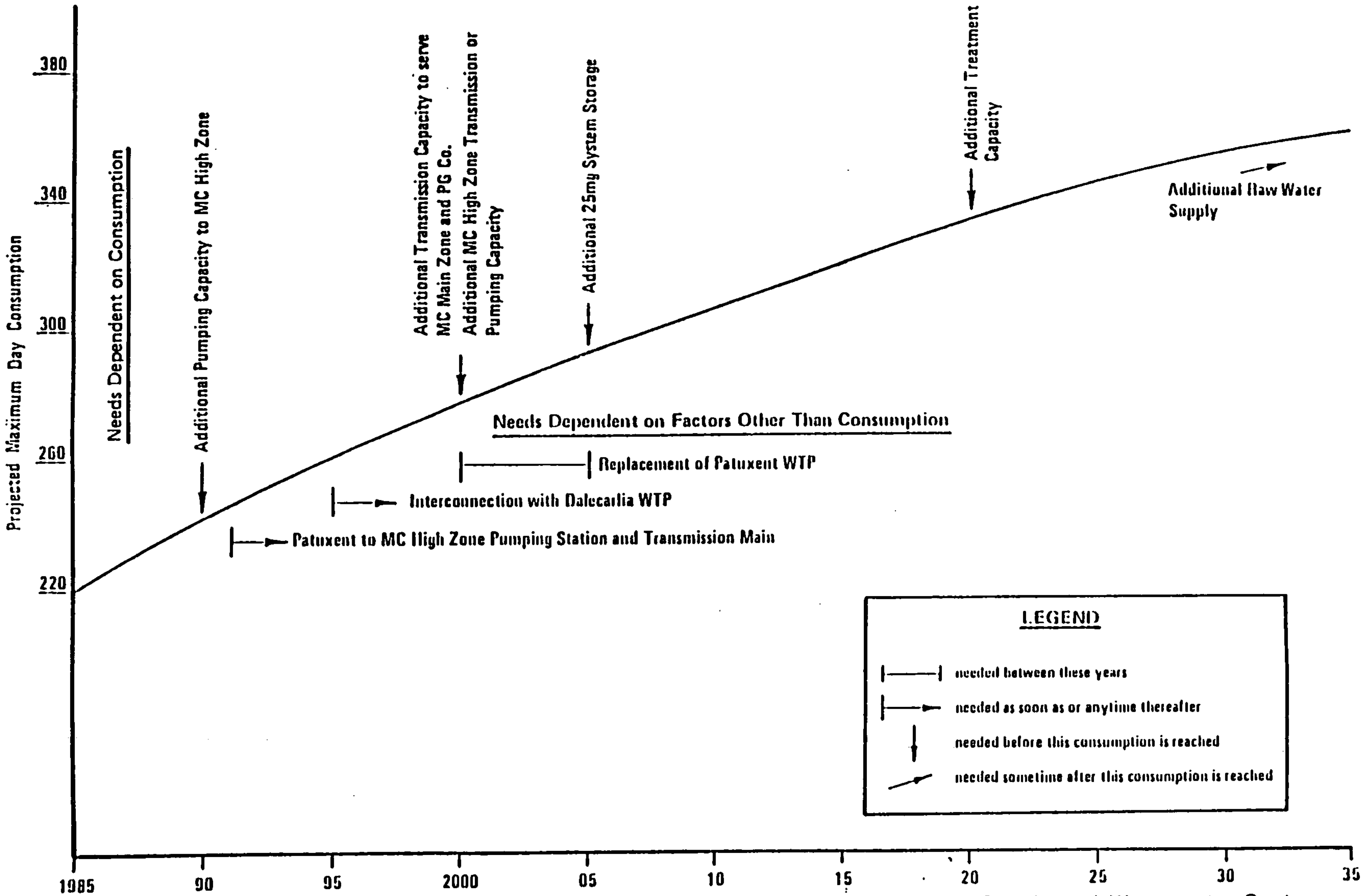
Information based on studies done by the Interstate Commission on the Potomac River Basin states that, in case of a reasonably severe event, such as repetition of the 1930 drought, the region's projected demands through the year 2030 could be met from the Jennings Randolph and other reservoirs.

The WSSC is currently conducting a multi-phase water system facility study for the Montgomery County and Prince George's County Main Zones to identify and evaluate alternative improvements to the system. Findings of the initial phase of the study are summarized as follows.

The current effective firm capacity of the Potomac Main Zone pumping station at the Potomac WTP is 195 mgd. The Potomac WTP is the primary source of supply to the entire system. This capacity is projected to be exceeded

FIGURE 9.1

SUMMARY OF MAJOR NEEDS FORSEEN FOR THE WSSC WATER SUPPLY SYSTEM



Source: A Comprehensive Long-Range Macro-Level Analysis of the WSSC Water Supply and Wastewater Systems, by Washington Suburban Sanitary Commission, July 1987

by year 2002 or 2008 depending on operational decisions. In order to remedy this constraint, WSSC is examining expansion of the Potomac pumping station and an interconnection between WAD's Dalecarlia WTP and the WSSC system.

The Main Zone transmission system conveys from the Potomac and Patuxent WTPs all areas of the main zones and to all dependent zones. The majority of the system transmission mains serve to distribute from Potomac WTP to the four major service zones. Project 80, the major transmission main carrying supply from the Potomac WTP to Prince George's County is expected to be repaired and replaced in service by 1995. Storage tanks near the beginning of Project 80 may be impacted by the lack of transmission capacity to supply the pipeline. This transmission constraint is projected to occur by 1990. Additionally, several segments of the transmission mains originating at the Potomac WTP and serving Montgomery County are projected to exceed safe flow velocities by year 2020. The ability to reduce these velocities is being evaluated for several alternative solutions. These alternatives include, but are not limited to, interconnections with the Potomac or Dalecarlia WTPs.

Existing storage for the Main Zone is being evaluated by WSSC for fire, emergency and equalizing volume requirements. Using engineering criteria, a storage deficiency of 10.9 mg for fire and emergencies has been identified for the Montgomery County Main Zone in the year 2020. WSSC is presently evaluating a new storage facility at the Rossmoor site on Georgia Avenue, underground pumped storage at the Northwood school site or pumped storage from the Potomac WTP as potential solutions.

The information in this section is from: *Comprehensive Water Supply and Sewerage System Plan*, Montgomery County Government, February 1986; *Washington Suburban Sanitary Commission Supply and Sewerage System Plan*, Montgomery County Government, February 1986; and *A Comprehensive Long-Range Macro-Level Analysis of the WSSC Supply and Wastewater Systems*, Washington Suburban Sanitary Commission, July 1987.

Section B: Sewerage Capacity

Estimates of demand for sewage treatment capacity suggest that substantial additional capacity will be needed prior to full development of the total number of jobs and housing units contained in any of the the scenarios.

The availability of sewage treatment capacity to serve the County's needs has improved steadily since the State-imposed moratorium on new construction during the 1970's. Interstate regional agreements on the shared use of an upgraded Blue Plains treatment plant in the District of Columbia, together with smaller satellite plants in the suburban jurisdictions, provided the solution to the problem at that time. According to current plans, the major future additions to capacity for Montgomery County will come from an expansion of the Blue Plains treatment plant in the District, and the

construction of the Rock Run plant at Avenel in the County. Smaller additions to capacity also will come from the release of some capacity at Blue Plains which is currently held in reserve, and from a proposed increase in the rated capacity of the Seneca plant within the County. (See Figure 9.2.)

Some additional capacity will come from an upgrading of the existing Damascus wastewater treatment plant from 0.9 to 1.5 mgd in the early 1990's. Based on current information, this facility would remain independent of the Blue Plains system and is not further addressed herein.

In spite of the increase in the existing and planned capacity available to the County, existing plans do not provide sufficient capacity to accommodate full buildout of the current zoning envelope. At some point, a major new program for capacity above that already planned will be necessary.

Figure 9.3 shows the relationship between (a) the maximum sewage treatment capacity available to Montgomery County under current regional plans, and (b) the treatment capacity necessary to serve two land use scenarios tested with the TRAVEL model.

Both the FAST and SLOW were tested.. They were selected because they represent the high and low ends of the range of sewage treatment capacity needed in the future.

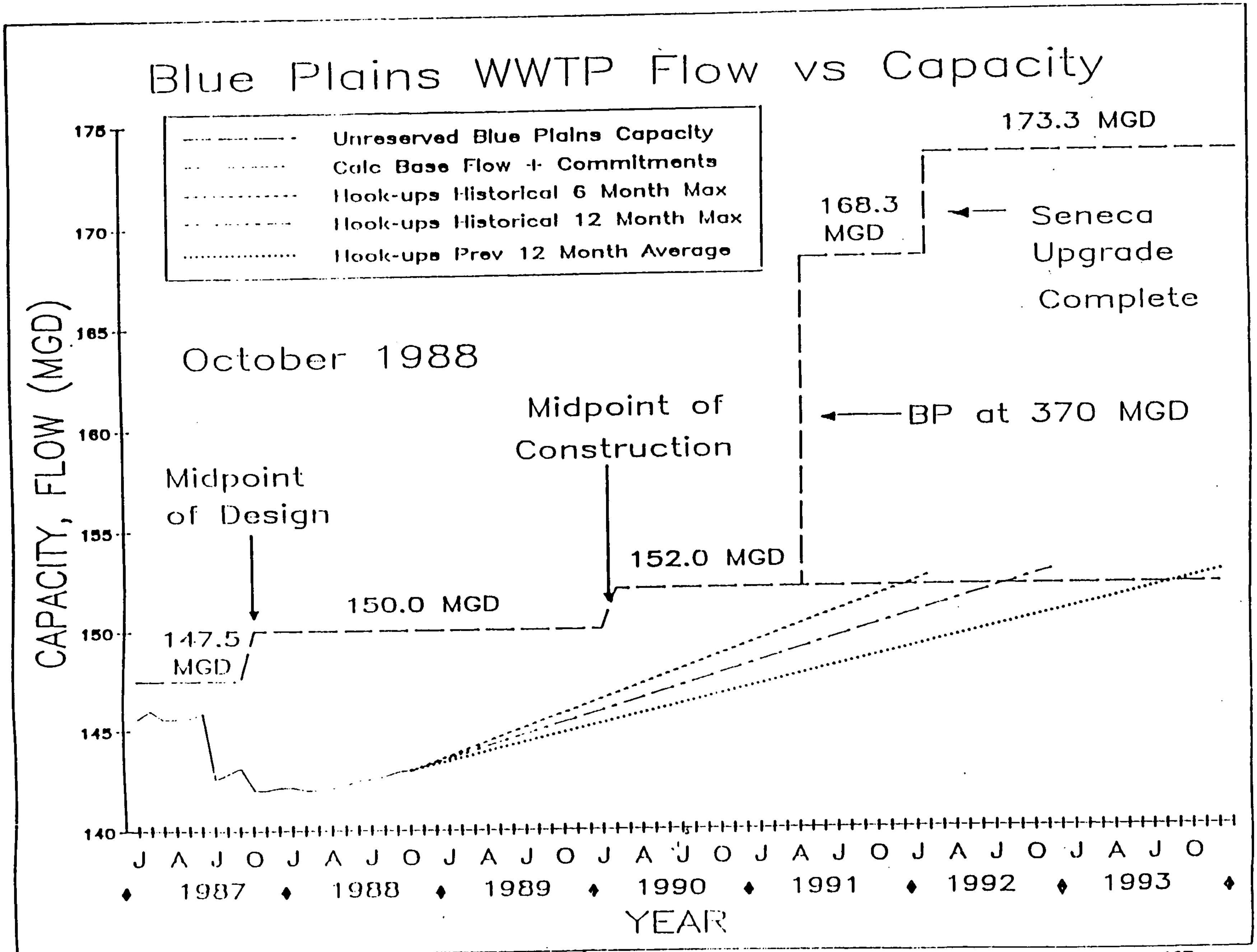
Figure 9.3 also shows three rates of potential flow generation extended to the year 2020. The lowest is based on sewer hook-ups for the period October 1987 to October 1988. The other two are based on historical 6 month maximum and 12 month maximum hook-ups.

These sewage flow generation rate projections, when compared with treatment capacity amounts, serve as a guide as to when advance planning should begin, to assure that plant capacity meets the growth expectations approved by the County Council. Montgomery County is currently programmed for up to 173.3 mgd capacity. Somewhere between 1999 and 2005, Montgomery County will need to have on line the capacity provided by the Rock Run sewage treatment plant. The only other source of potential additional capacity apparent at this time would be at an expanded Seneca plant, which might be expanded beyond its currently programmed 10 mgd.

At present, no additional plants have been planned to take care of future needs after the Rock Run plant reaches capacity. Assuming the projected flow rates are reasonably probable, a major new facility for Montgomery County will be needed somewhere between 2006 and 2016. Its ultimate size will depend on future growth, but will likely be in the range of 32 to 110 mgd.

There is time therefore, to plan how to accommodate the sewerage needs of the selected scenario. It is prudent to begin such planning in the near future, rather than wait

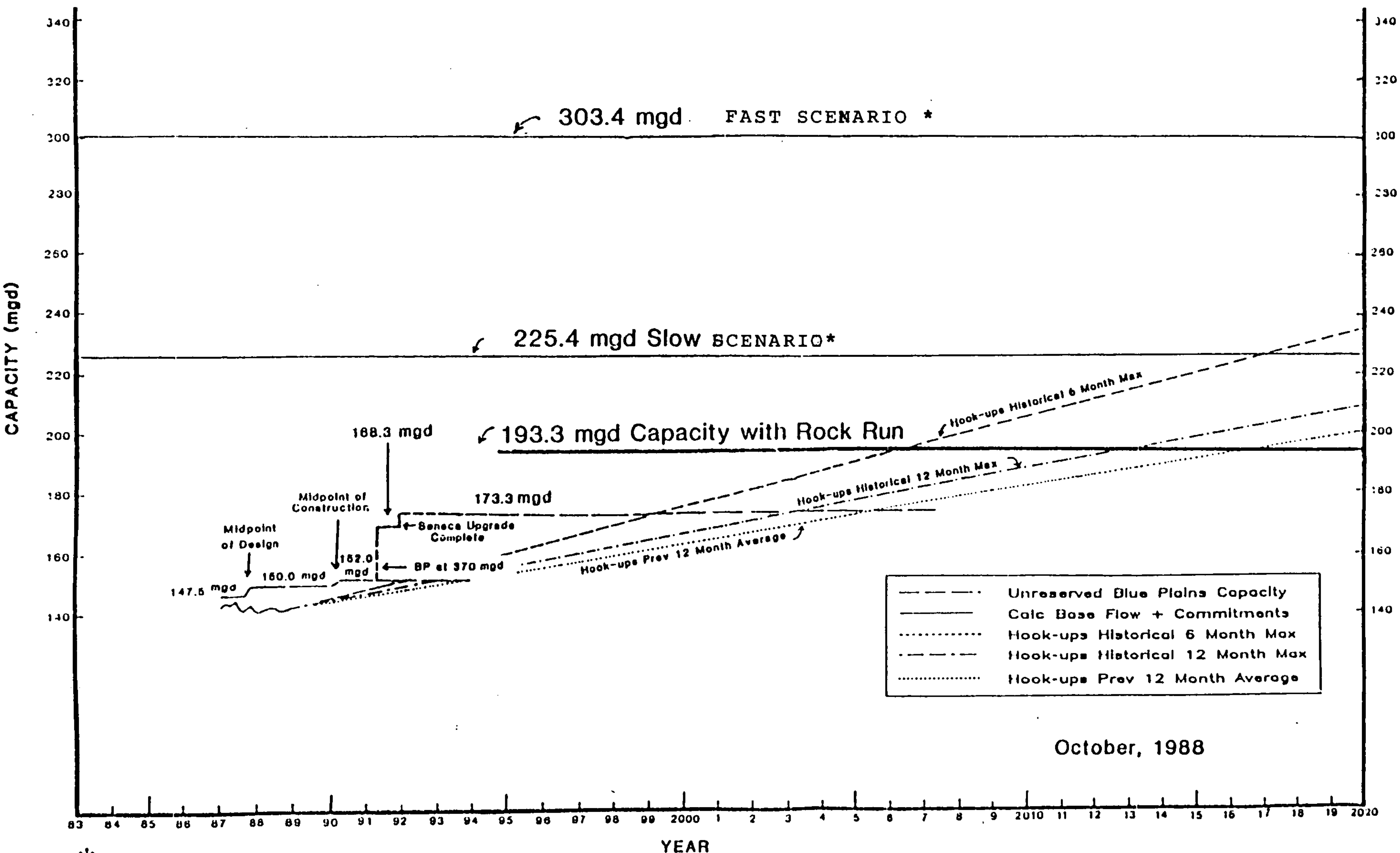
FIGURE 9.2



Source: WSSC
Memo from Cy Jones, December 7, 1988

FIGURE 9.3

Blue Plains WWTP Flow vs Capacity



* Includes Prince George's County

Source: Washington Suburban Sanitary Commission & Environmental Planning Division, M-NCPPC

10 years, to permit land acquisition for sewage treatment plants and transmission lines before the opportunity and cost become prohibitively difficult and high. It probably will be extremely difficult to find a cost-effective location in Montgomery for a plant of the size needed, and it appears that, upon expansion to 370 mgd, no additional capacity could be obtained at Blue Plains. This leaves the most likely location to be in Prince George's County, either at the existing Piscataway facility or some new location. Location and construction of both the plant and lines may present difficult problems, but the trunk transmission line question may be the most complex. Other solutions may present themselves, such as distribution of flows to several smaller plants. Such solutions need much more detailed study.

Sewerage Collection System

Expansion of the sewerage system to accommodate any scenario will require major sewer main construction. If additional sewage plant capacity is to be located below the District of Columbia, new trunk lines, force mains, and pumping stations will be needed not only within the Montgomery County service area, but also through the District of Columbia and Prince George's County.

Figure 9.4 shows that the major growth areas shown on the General Plan, the western and northern section of the County, all drain towards the Potomac River. At present the Dulles Interceptor sewer line picks up this drainage pattern and transports it, through rock tunnels, under the densely developed areas of the County and District, inside the Route 495 Beltway, to the Blue Plains regional plant on the south side of the Anacostia River. If a new sewage treatment facility, for the capacity needed beyond what is already planned, is to be located south of the District of Columbia, major new sewer trunkline will be needed through the same area. Alternatively, other treatment plant locations will need to be found.

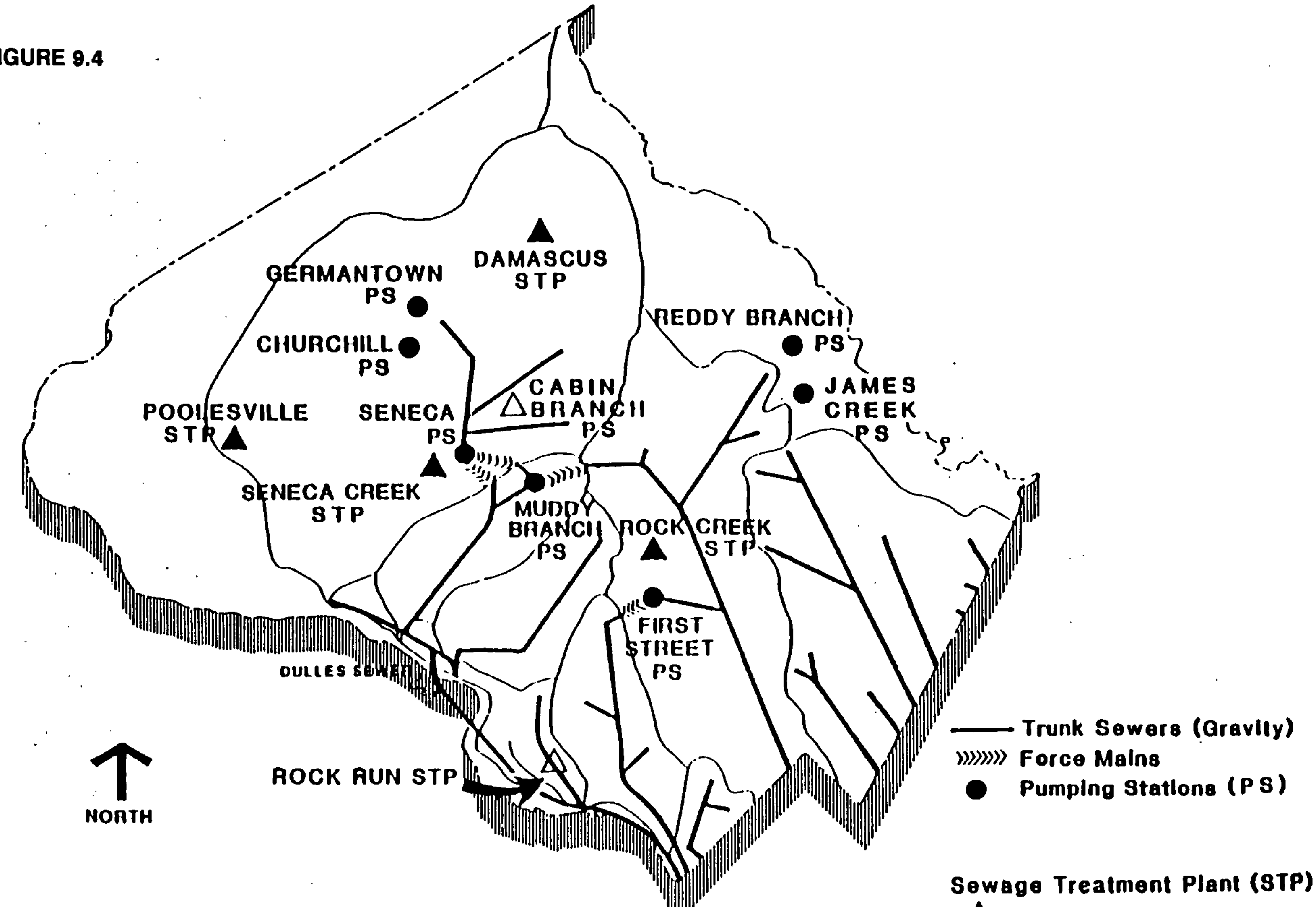
WSSC has recently completed the Western Montgomery County Facility Plan, a wastewater management plan for western Montgomery County, which includes Seneca and Muddy Branch basins. This is the area where a significant portion of the future County growth is expected to take place.

Some of the major conclusions and recommendations of that facilities plan are listed below.

* Blue Plains service area treatment capacity will be exceeded in 1992 if the Blue Plains wastewater treatment plant (WWTP) expansion is delayed beyond then, and between 2000 and 2005 with the Blue Plains expansion.

* An upgrade of the Seneca wastewater treatment plant to 10 mgd is recommended. Water quality modeling has indicated that expansion up to 28 mgd is technically feasible. WSSC recommends acquisition of 156 acres adjacent to the plant based on a 500 foot buffer.

FIGURE 9.4



SOURCE: M-NCPPC
COMPREHENSIVE TEN YEAR WATER AND SEWERAGE PLAN

Schematic Sewerage System

* Other system improvements are described in detail in the facility plan.
* It is recommended that the best alternative to meet the needs of the Blue Plains Service Area be determined by a Blue Plains Service Area Regional Facility Plan new study.

Future Conveyance Requirements

As part of the previously noted western Montgomery County facility plan, the WSSC used a computer model to determine inadequacies in transmission capacities. Results of that analysis are listed below. It was assumed in the study that the Seneca treatment plant would be treating 4.3 mgd average daily flow and about 4.5 mgd peak flow. (Refer to Figure 9.5)

1) Sewer carrying capacities in portions of Seneca and Muddy Branch trunk sewers would be exceeded by 1990.
2) The Seneca pumping station would have insufficient capacity to transfer peak flows to Muddy Branch under existing flows.
3) The capacity in much of the Branch "H" sewer would be exceeded by 1990.
4) The capacity in portions of the Whetstone Run and Cabin Branch sewers would be exceeded by 2005.
5) Montgomery County's allocation in the Dulles Interceptor would be exceeded as early as 1990 in one segment, and a few years later in other segments too. It should be noted that the Dulles Interceptor has adequate capacity to carry the flow. It is the existing institutional arrangements that seem to be the mechanism that needs amendment in the short run.
6) The limiting maximum capacity of Segment 1 of the Project "C" sewer (system of sewers in the District of Columbia that will carry flow from the Dulles Interceptor) would be exceeded by year 2000, and the limiting maximum capacity of Segment 3 would be exceeded by year 1990.

In addition to these constraints in western Montgomery County, the Rock Creek and Anacostia basins are also expected to face major constraints. (From the 1987 WSSC report *A Comprehensive Long-Range Macro Level Analysis of the WSSC Water Supply and Waste Water Systems.)*

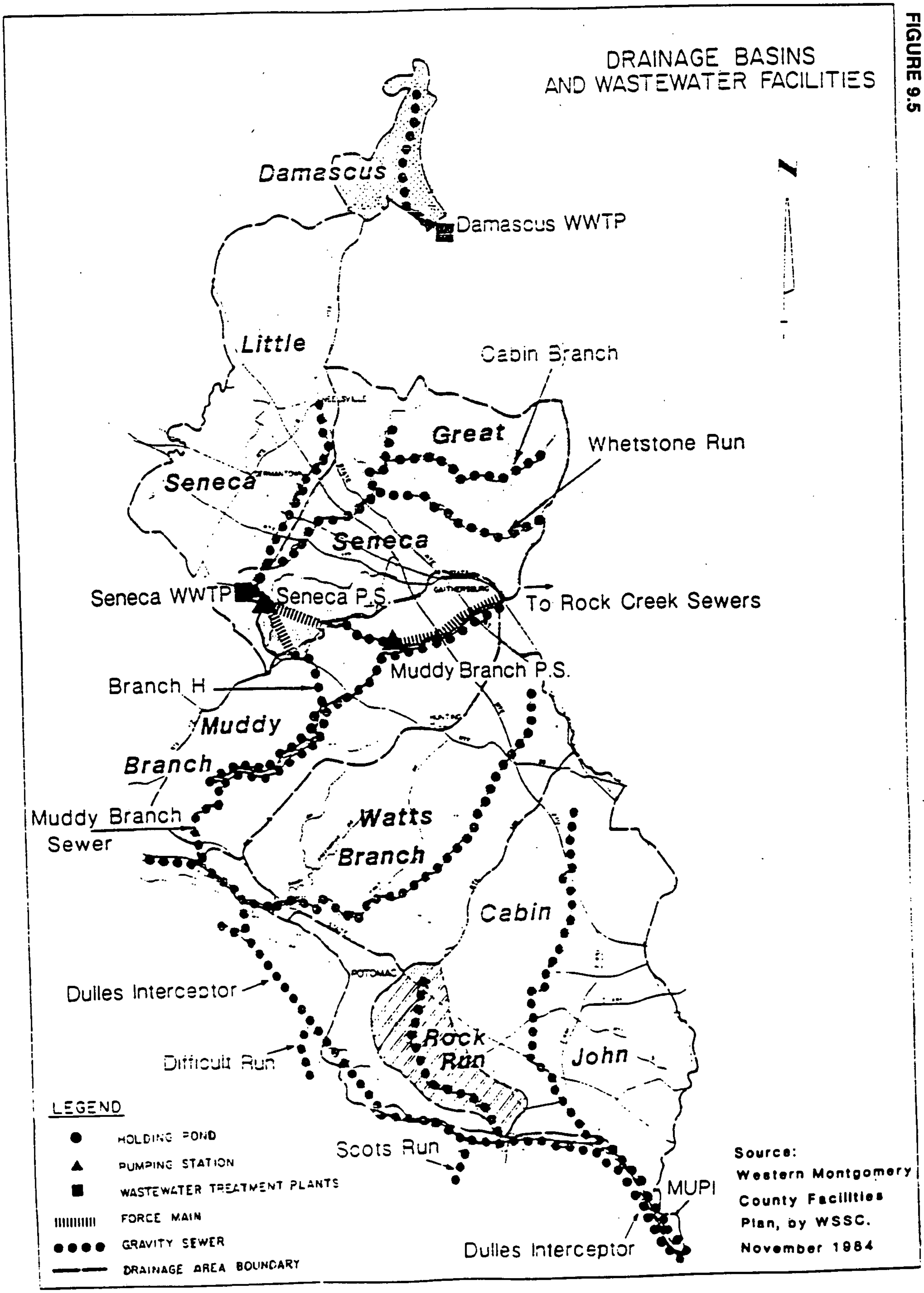
The WSSC is also studying the Cabin John Basin to determine if previously projected system constraints will require capital expenditures. (From the 1989 WSSC report, *Cabin John Re-evaluation Study: Draft Feasible Alternatives and Evaluation Criteria Interim Report.)*

Programming of system improvements will take place through the CIP process as actual flow levels approach the projected quantities, as measured by the WSSC.

Rock Creek Trunk Sewer

Construction of the Rock Creek storage facility will provide a conveyance capacity of 36.6 mgd average flow for

FIGURE 9.5


DRAINAGE BASINS AND WASTEWATER FACILITIES
Damascus
Damascus WWTP
Little
Cabin Branch
Great
Whetstone Run
Seneca
Seneca
Seneca WWTP
Seneca P.S.
To Rock Creek Sewers
Muddy Branch P.S.
Branch H
Muddy Branch
Muddy Branch Sewer
Watts Branch
Cabin John
Rock Run
Dulles Interceptor
Difficult Run
Scots Run
MUPI
Dulles Interceptor
LEGEND
HOLDING POND
PUMPING STATION
WASTEWATER TREATMENT PLANTS
FORCE MAIN
GRAVITY SEWER
DRAINAGE AREA BOUNDARY
Source: Western Montgomery County Facilities Plan, by WSSC. November 1984

the Rock Creek basin. Projected flows will reach this amount by 2002. Any flows beyond this capacity will have to be handled in another basin via a pumpover. Any pumpover would encounter difficulties in implementation similar to those for other facilities discussed previously.

Anacostia Wastewater Pumping Station (WWPS) and Force Main

As previously discussed, hydraulic constraints currently limit the two Anacostia wastewater pumping stations to pumping a peak flow of 100 mgd. Peak flows above this amount are overflowed. Thus, an accurate measurement of current peaks cannot be made. However, based upon flow estimates, it is believed that when the force main is put in service, the Anacostia WWPS No. 2 should provide sufficient capacity for projected 2030 flows.

Cabin John Relief Sewer

Relief sewers have been constructed parallel to the main sewer for the lower portion of the Cabin John basin. Extension of this relief sewer system has been planned for implementation in the next several years. However, a stabilization in urban development combined with significant infiltration and inflow reduction within the basin have raised a question about the necessity for the sewer. The WSSC has initiated a facility plan, the Cabin John Re-evaluation Study, to determine if the relief sewer project, or an alternative relief measure, is still required. The study also considers the potential impact of receiving flows pumped from the Rock Creek basin. The facility plan should be completed by the end of the year 1989.

Sewerage Demand: FAST Scenario

Households (600,000 x 285 gal./d.u.)	171.0 mgd
Jobs (900,000 x 70 gal./employee)	63.0 mgd
Prince George's County (estimate)	69.4 mgd
Total	303.4 mgd

Sewerage Demand: SLOW Scenario

Households (400,000 x 285 gal/du)	114.0 mgd
Jobs (600,000 x 70 gal/employee)	42.0 mgd
Prince George's County (estimate)	69.4 mgd
Total	225.4 mgd

Source: *A Comprehensive Long-Range Macro-Level Analysis of the WSSC Water Supply and Wastewater Systems,* Washington Suburban Sanitary Commission, July 1987

Section C: Water and Sewer Costs

The fiscal impact of the Washington Suburban Sanitary Commission's (WSSC) budget was not analyzed as part of the main fiscal analysis of the CGP Study because it is separate from the County budget and funded almost entirely by user fees instead of taxes. Montgomery County and the bi-county area will face some major capital costs

for sewer and water treatment and transmission between now and 2020.

Sections A and B above give an overview of the upcoming constraints imposed on growth by the water and sewer system and the capital projects needed to relieve them. Appendix 7 outlines how water and sewer costs were estimated for this Study. This review includes an estimate for capital projects of 1.11 billion dollars assuming about eighteen percent funded by grants. Spread over 30 years, $1.11 billion is $37 million per year resulting in an average annual debt service of $61.9 million. This assumes that the County's share of capital is funded with 20 year bonds at 8.0 percent interest. WSSC's FY 1988 debt service was 74.6 million dollars, about a third of their budget.

The total WSSC CIP costs for Montgomery County and bi-county projects for the four year period from FY 1988-1991 are $286 million, or $71.5 million per year. These CIP projects are included in the $1.11 billion estimate. If spending at this pace were continued over a 30 year period it would amount to 2.144 billion dollars and would result in annual debt service of about 119 million dollars. This would be considerably more than the 30 year need of $1.11 billion. While it is clear that the costs for water and sewer service will rise in the next few years to accommodate the projects now being undertaken, spending at this high a rate will not have to continue for 30 years to accommodate even our fastest growth scenario.

Section D: Solid Waste

Appendix 7 also deals with solid waste. Solid waste disposal estimates were developed based on informal discussions with County staff and MCPD Environment Division information. Under the FAST scenario, the 30 year capital requirements for solid waste disposal are estimated to be 750 million dollars with no federal or state funding. This would generate debt service costs of 51 million dollars per year. The County DEP (Department of Environmental Protection) currently spends 6.7 million dollars per year in debt service from its special debt service fund. It may underestimate current capital spending because of substantial funding from current disposal fee revenues.

Section E: Impact Of Dense Versus Sprawled Development

The 1974 study, *The Costs of Sprawl*, is probably still the most authoritative treatment of the differences in environmental costs that result from different development and transportation networks. Its conclusions are well covered in the summary of the study and a graph from the study that are included as Appendix 8. The study concluded, generally, that higher-density development resulted in lower environmental costs in terms of water and sewerage demand per household, water pollution, air pollution, and developed land. It also concluded that higher-density development resulted in lower energy consumption.

The obvious implication of the analysis in *The Costs Of Sprawl* is that more clustered land use and transportation networks, such as those required for the RAIL pattern and, to a lesser extent, the VAN pattern, will have lower environmental costs and lower energy consumption.

For example, automobiles are the single largest source of air pollution. A shift away from the AUTO pattern would obviously reduce both air pollution and energy consumption. The sewage system costs associated with a FAST/RAIL scenario would be less than those associated with a FAST/AUTO scenario.

These issues, as well as the issue of the greenhouse effect, are addressed in more detail in the Global Factors volume of this Study. That volume was prepared by consultants as a separate study in recognition of the need to include evaluation of issues like air pollution, petroleum dependency, and the greenhouse effect. These are issues that can best be seen at large scale and are difficult to quantify or address for the County alone.

Chapter 10

Traffic and Fiscal Evaluations

CHAPTER TEN: TRAFFIC AND FISCAL EVALUATIONS

Pattern, Pace, Proportion, and Price

Imagine that one could take a snapshot of the County as it would exist in the year 2020 and, from this snapshot, one could measure the traffic and fiscal characteristics of the County as they would exist in that year. Chapter One has described a set of such snapshots. This chapter describes the results of the traffic and fiscal tests. The purpose of these tests is not to make a prediction, but rather to see what relative differences there are among the different scenarios. The focus, therefore, is on relative proportions rather than absolute numbers.

The scenarios were constructed to permit comparison across three key dimensions, which are called herein Pattern, Pace and Proportion. Pattern refers to the relative degree of spatial clustering and concentration that occurs in the land use layout. Its effects are measured by comparing the traffic and fiscal characteristics of the three geographic scenarios, ranging from AUTO through VAN to RAIL. Pace refers to how rmuch growth takes place within a given period of time. Its effects are measured by comparing the traffic and fiscal characteristics of the FAST and SLOW economic scenarios. Proportion refers to the ratio between the number of jobs and the number of housing units in the County. Its effects are measured by comparing the traffic and fiscal effects of the JOBS and HOUSING economic scenarios.

Public discourse on growth issues frequently oscillates back and forth across the three dimensions of Pattern, Pace and Proportion. When we worry about housing spreading to the exurbs and creating long commuting patterns, we are focusing on the Pattern dimension. When we worry about rapid growth creating congestion, we are focusing on the Pace dimension. When we worry about the shortage of housing, we are focusing on the Proportion dimension.

In the real world, all three factors are intertwined. In the following sections, an effort is made to see if the traffic and fiscal test results shed any light on the relative importance of the three dimensions of Pattern, Pace and Proportion.

As this study progressed, it became increasingly clear that a fourth dimension, called Price, also plays a significant role. Price refers to the relationship between the price of goods and services and the income of whatever constituency is relevant to the factor under discussion. When we talk about "affordable" housing, we are focusing on the Price dimension. Analysis of this dimension of the growth issue is very difficult at present, primarily due to a lack of adequate data. An effort is made to address it here, but further work is necessary before any clear proportional relationships between this dimension and the other three can be asserted with confidence.

TRAFFIC IMPLICATIONS

The Traffic/Mode Share Chart

Figure 10.1 shows the outcome of applying the traffic model to ten of the combined scenarios. Each composite scenario is identified by two letters and a hatched pattern. The large letter stands for its economic characteristics. The small letter stands for its geographic characteristics. The hatched pattern stands for the level of the Transit Incentives and Enhancements (TIE) package (see Chapter 6).

The vertical axis shows the level of traffic congestion produced by each scenario on an average County-wide basis. The measurement method counts the total number of vehicle miles traveled in the County at different levels of traffic congestion, and aggregates them all into one measure of average County-wide congestion. This is the same technique currently used in the Annual Growth Policy (AGP). In the case of the AGP, the aggregation is done for each policy area of the County. In the case of this study, the aggregation is done for the County as a whole.

All averaging techniques have the effect of washing away the awareness of unique local characteristics. This measurement shares that effect, and, because it applies to an area larger than the policy areas used for the AGP, the loss of local detail is even greater. It must, therefore, be recognized that this is a crude measuring tool but, nevertheless, one that offers an opportunity to compare the alternative scenarios to a reasonable degree.

The horizontal axis shows the percentage of all work trips that are made by persons driving an automobile. By definition, the remaining percentage of non-drivers are people who travel by a different mode. Either they are passengers in a private vehicle, which may be defined as a carpool or vanpool, or they are passengers on a bus or Metrorail, or they use other forms of transportation, such as walking or bicycling. Figure 10.2 shows the approximate proportion of the non-auto driver trips for several different scenarios, divided among the following modes: auto passenger, drive to transit, walk to transit, and walk/bike.

The Level of Service Standard

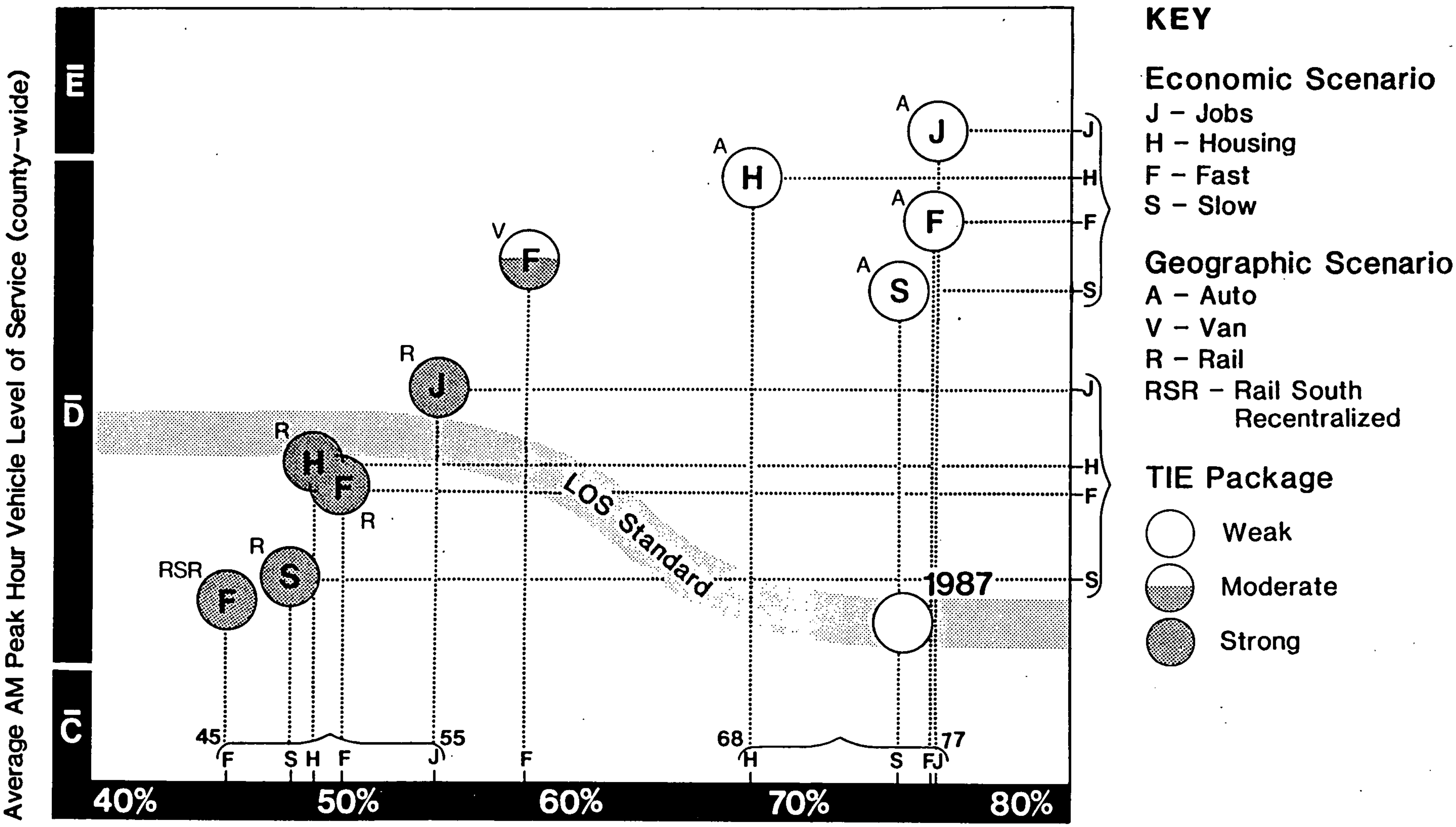
It should be noted that the shaded band on Figure 10.1, designated as the "LOS Standard," is an average County-wide benchmark drawn from the standards currently used in the FY 90 AGP. It rises from its current 1989 level, shown at the right-hand side of the chart in the low end of the D "level of service" range, to a new position in the middle of this range, shown at the left-hand side of the chart, because of the assumption that the RAIL scenarios will introduce much more transit to many more areas of the County. In accordance with the principles used in the AGP, it is appropriate to allow somewhat higher levels of congestion than might otherwise be permitted, where alternative travel oppor-

TRAFFIC

EFFECTS OF ALTERNATIVE SCENARIOS

Montgomery County Comprehensive Growth Policy Study

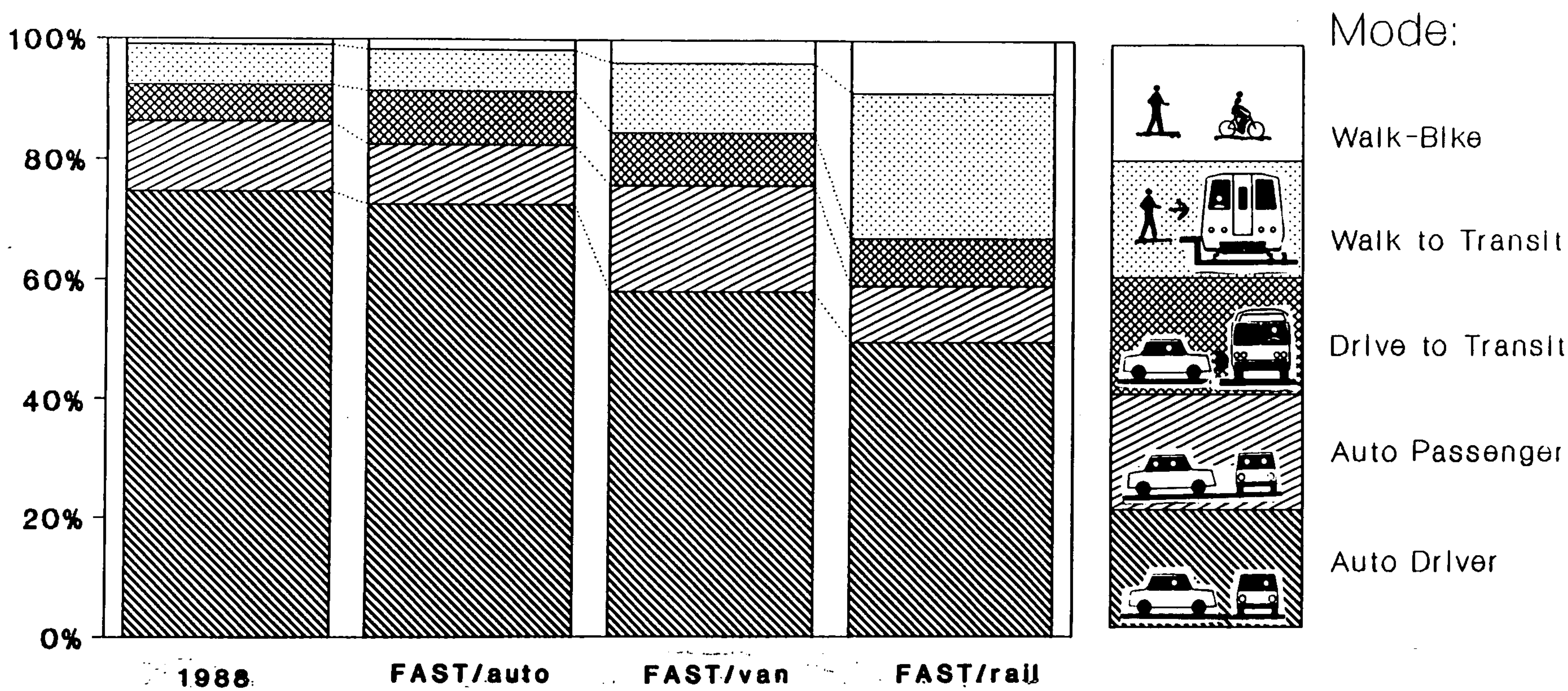
FIGURE 10.1



Average Auto Driver Share of all Work Trips

FIGURE 10.2

Montgomery County Origin Mode Share for Home to Work Trips



tunities to the private automobile are available through transit.

Effects of Pattern

If we examine Figure 10.1 from the Pattern perspective first, we can observe that all the AUTO scenarios show a much higher level of traffic congestion than do the RAIL scenarios. The VAN scenario is a special case, and will be mentioned further below. The conclusion must be drawn that the difference in Pattern between the AUTO scenarios and the RAIL scenarios produces a very significant effect on traffic congestion. Pattern appears to be a very important factor.

A corollary observation is that all the AUTO scenarios cluster at the high end of the auto driver share of the work trip (i.e., about 75 percent); and all of the RAIL scenarios cluster around a significantly lower proportion for this share (i.e., about 50 percent). The fact that a reduction in traffic congestion accompanies a reduction in driver trips may be considered a truism. But it also may be worth noting that Figure 12 gives some feel for the magnitude of the reduction in auto driver share that needs to take place (i.e., from 75 percent to 50 percent).

On a County-wide average basis, this is a very significant reduction from today's situation. A change in behavior of this magnitude will not be accomplished easily. In the absence of such a shift, however, all of the economic scenarios, including the SLOW scenario, will result in what today are considered to be unacceptable levels of traffic congestion.

Pattern and the Van Scenario

Some observations should be made about the implications of the geographic patterns of the VAN scenario. The FAST/Van scenario shows a significant drop in auto driver trips, which is not matched by an equivalent reduction in vehicle traffic congestion. Although there is a slight drop in congestion, it is not as great as simple common sense might expect. The explanation for this is that the installation of a designated lane for High Occupancy Vehicles (HOV) in many cases requires the removal of the lane from usage by Lone Occupancy Vehicles (LOV). Even at three persons per car pool on the HOV lanes (which the test assumed), a lot of LOV automobiles remain on the now-reduced number of roadway lanes, so that the overall auto congestion level (which is measured only on the basis of these lanes) remains high.

This is not to say that carpooling is not effective from a larger perspective. The fact that the LOV general auto lanes remain at high congestion levels does not tell the whole story. With an auto driver share reduced to below 60 percent, the VAN scenario shows that a large share of the total work trips would no longer be experiencing the high auto vehicle congestion that applies to the 60 percent on the roadways. These trips are traveling either by carpool, in which case they move faster on their dedicated lanes than the regular auto drivers in the traffic

flow, or by transit, where similar speed differentials are expected to apply. Indeed, it is the existence of a significant speed/time difference between travel by HOVs and LOVs that is a key motivating factor in the formation of car pools.

The general problem for carpooling in polycentric urban areas is whether one can travel at high speed on an extended and interlinked network to a variety of destinations. To the extent that HOVs get caught in the general traffic flow, the major advantage that they enjoy over LOVs is reduced. Staff concludes that the success of carpooling from an overall work trip perspective is highly dependent on the existence of a single dominant employment center with radial HOV facilities or on a large scale interlinked network of HOV pathways, on dedicated rights-of-way serving multiple employment centers.

The same observation also holds true for buses. By definition, rapid rail and light rail normally use a separate right-of-way, unencumbered by general automobile traffic. Buses, however, typically use the common road surface and mingle with general car and truck traffic. This reduces the speed of the bus and significantly enlarges the overall elapsed time for the transit trip, even if part of it is by rail. Thus, a really significant transfer of commuters from LOV's to buses also depends to a large degree on the ability to provide a large scale, interlinked network of busways on dedicated rights-of-way, or alternatively, on regular roadways with "circuit-breaker" techniques that give buses priorities within the general traffic at intersections.

Time did not permit testing the VAN scenario with the use of buses on the HOV lanes in addition to carpools. Staff assumes that when this is done, it will reveal a significant reduction in traffic congestion. Because of the newness of the HOV phenomenon, there is little national experience in measuring its effects. Further staff work is being undertaken to continue to explore this important concept, and to identify its appropriate place between the auto and the rail alternatives, with which we have more experience, and therefore, better definition. Chapter Three explores future possibilities with regard to the VAN scenario in greater detail.

Importance of the TIE Package

It must be noted that the lower traffic congestion levels of the Rail pattern scenarios are dependent on the installation of a strong Transit Incentives and Enhancements (TIE) package. This cluster of economic incentives (e.g. increased parking costs) and hiker-biker enhancements (e.g. local pathways) plays a large role in permitting as many trips to be diverted from Lone Occupancy Vehicles (LOV's) as the TRAVEL model shows. Without the addition of this ingredient, the land use and network assumptions of the RAIL scenarios would show considerably higher levels of traffic congestion.

A short commentary seems warranted. It is obvious that the greatest single leverage over traffic congestion is

that which can be exercised by individual human choice. In the Third World, people commute long distances on foot and bicycle. Even as recently as twenty-five years ago, the auto driver share of the work trip in Montgomery County was only 65 percent. It is clear that human behavior has great leverage over traffic congestion. A preference for automobile driver behavior cannot produce an automobile where none is available. But where alternative modes do exist, the aggregate choice of one over another makes a big difference in cumulative result.

The RAIL scenarios explore the combined effect of influencing behavior by: (1) locating more homes and jobs near each other and near transit, and (2) providing attractive transit alternatives to the private automobile. Figure 10.3 is a diagram of the many factors that influence this behavior, and on which further work is proceeding. Figure 10.4 illustrates diagrammatically the implications for the mode share of the work trip that derive from the two factors of: (1) land use clustering; and (2) transit networks. Controlling both of these elements involves costs, the first in terms of the social costs of amending zoning patterns and defending them against property owner litigation, and the second in terms of the fiscal costs of constructing new facilities and defending them against objections at the polls.

What is not yet clear to anyone in the nation, so far as we can tell, is the degree to which the American people will switch voluntarily from driver mode to alternative mode, simply as a consequence of changing the physical land use and transportation network patterns. Because of this uncertainty, the RAIL scenarios in this traffic test assume the existence of a strong TIE package.

Obviously, the estimating of human travel behavior that involves change of this magnitude is highly speculative. The designation of some benchmark assumptions with regard to the elements of the TIE package, as shown in Figure 10.1 and described earlier in Chapter 6, makes it a little easier to make the estimates of mode shift that were used in the TRAVEL model for this study. A significant work effort is ongoing in the Planning Department to attempt to obtain better data and better forecasting techniques with which to refine and improve this necessary component of the transportation planning needs of the future.

Effects of Pace

With regard to Pace, Figure 10.1 shows that the SLOW scenario indeed produces less traffic congestion than the FAST scenario, under either the Auto or Rail pattern. Since the transportation network is assumed to be the same for both the FAST and the SLOW scenarios, this result is a logical and necessary outcome of the fact that the SLOW scenario shows only about a third as much new growth as the FAST scenario.

More important, however, than the fact that the SLOW scenario shows less congestion than the FAST scenario, is the fact that there is such a relatively small difference in congestion between the two scenarios in the Auto pat-

FIGURE 10.3 **Travel Behavior Factors Relating to a Trip From Home to Work**

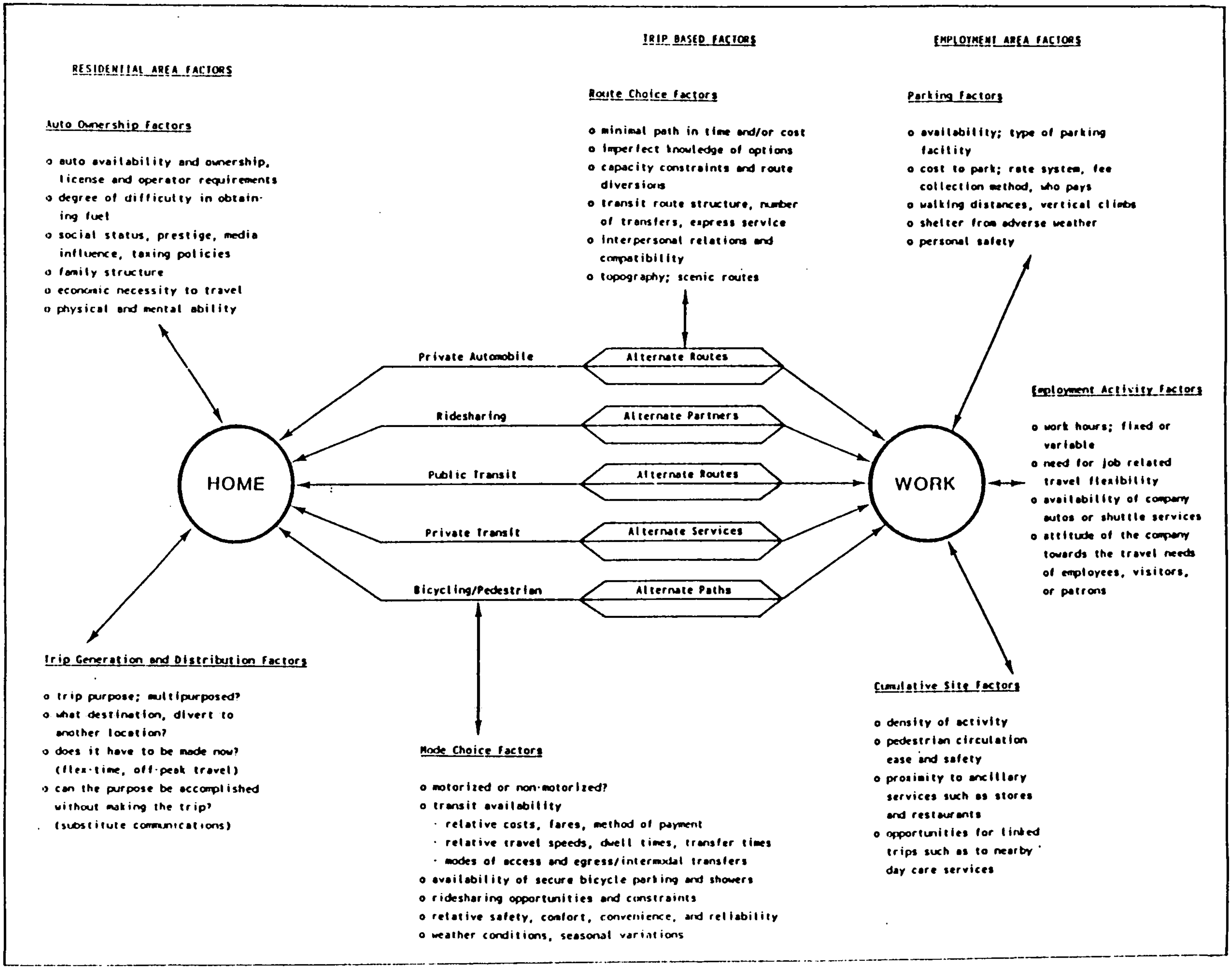
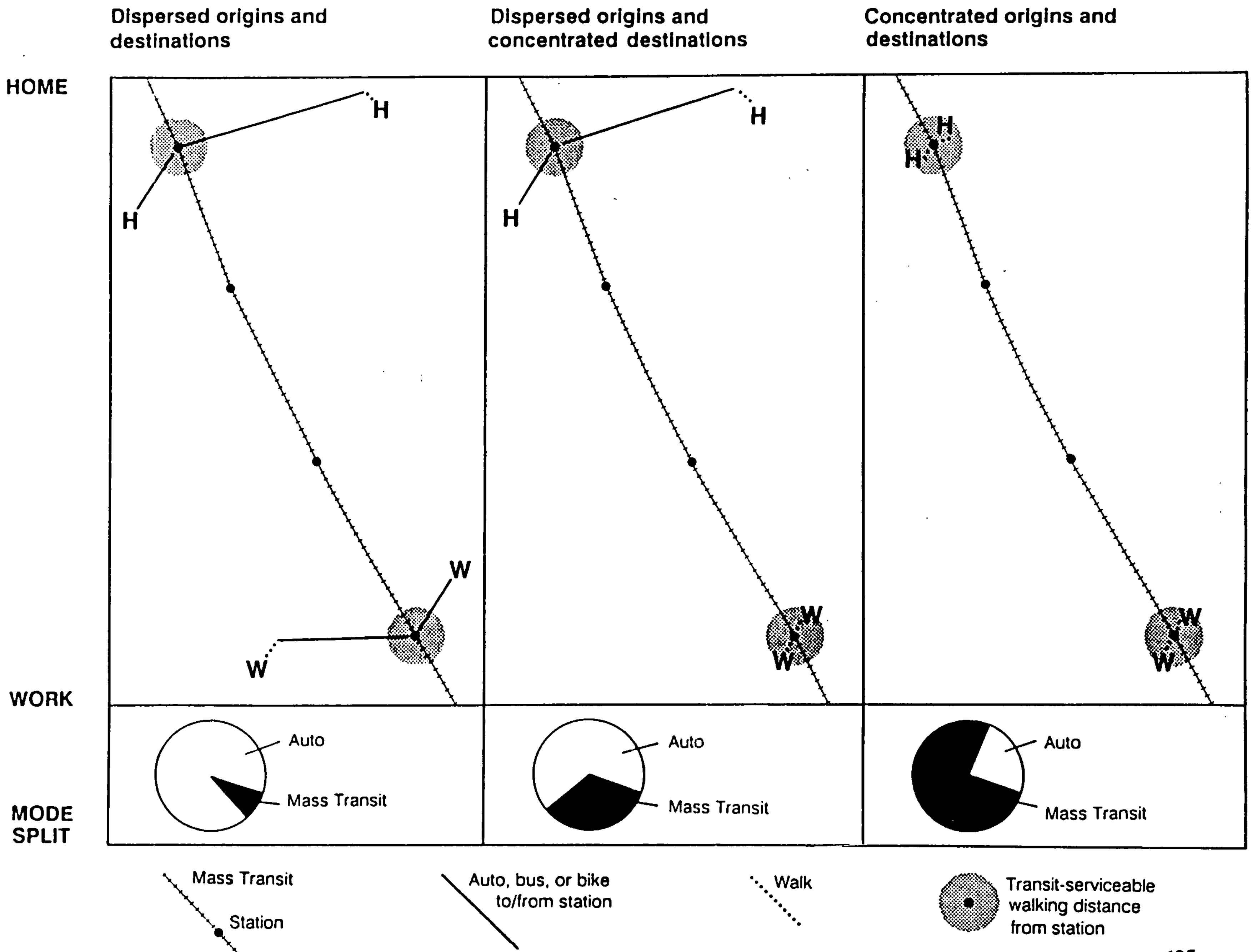


FIGURE 10.4 **Transit Access Diagram**



tern. Although the relative congestion levels of the SLOW and FAST scenarios in the Rail pattern seem consistent with their relative amounts of growth, the same is not true for the Auto pattern.

Here the fact that the SLOW scenario results in so much congestion is due to the fact that the test assumed that the rest of the region would continue to grow to the TREND level. This test illustrates the fact that, unless the rest of the region's growth can be slowed down to the same level as Montgomery County, the adoption of an extremely slow growth scenario by Montgomery County, even if it could be implemented, would not accomplish a great deal in terms of reducing traffic congestion.

Under the Rail pattern, this is not true to the same extent. However, it must be remembered that part of the Rail network involves transit connections laterally into Fairfax and Prince George's counties, and that the same total amount of new rail network was assumed for both the FAST and SLOW scenarios. Thus, the reduction in traffic congestion between FAST and SLOW that is revealed in the Rail pattern is dependent on both a regional light rail, or other transit, connection agreement, and a high level of new transportation investment by Montgomery County.

Whether both of these conditions could be met in the real world under a slow growth scenario is questionable.

Pattern versus Pace

What may be of greater significance is the comparison between the effects of Pace and those of Pattern. The traffic congestion produced by the SLOW scenario in the AUTO pattern is far greater than the congestion produced by the FAST scenario in the RAIL pattern. This suggests that how the County grows in *space* is more important than how it grows in *time*. Pattern appears to be relatively more important than Pace insofar as traffic congestion is concerned.

Effects of Proportion

With regard to Proportion, the TRAVEL model tests support what common sense would assume, namely that the JOBS scenarios, in both the Auto and Rail patterns, produce more congestion than the HOUSING scenarios. Common sense would assume that with an excess of jobs, there will be many in-commuters from outside the County, whose long trips will congest the arterial roads through the County to the job destinations within the County; and that, conversely, if the County is in the posture of exporting workers, as is the case in the HOUSING scenario, the outflowing trips from homes in the morning would either flow south towards the District of Columbia and related places, where those trips can be made on transit, or they would flow north to jobs in the exurban counties, where the trip would be against the predominant flow, and, therefore, would encounter less congested situations.

This finding is sensitive, however, to the distribution of employment growth in the region outside Montgomery County. If employment growth in other low density, automobile dependent suburbs and exurbs of the Washington region should become stronger than was assumed in this test, and employment growth in the transit dependent District of Columbia should become weaker than was assumed, an Auto pattern HOUSING scenario could produce traffic congestion worse than an Auto pattern JOBS scenario. This would be because more work trips by County residents would be forced to rely on the automobile for the trips to and from these suburbs and exurbs. More is said below about the effect on Montgomery County of alternative regional growth patterns outside the County's border.

Another interesting observation involves the comparison between the FAST scenario and the JOBS and HOUSING scenarios. Under both the Auto and Rail pattern alternatives, the FAST scenario shows significantly less congestion than the JOBS scenario, and even slightly less than the HOUSING scenario. Recalling that the number of jobs in the FAST scenario is the same as in the JOBS scenario, it seems evident that the reduction in traffic congestion from the JOBS scenario must be primarily due to the addition of housing to the JOBS scenario.

This is an interesting result. Staff speculates that it is due to the shortening of work trips, between housing units in the County and employment in the County, compared to the length of the work trip from houses outside the County to jobs in the County in the JOBS scenario. Such a reduction in trip length would result in the TRAVEL model showing less vehicle miles traveled on congested roadways, which would reduce the overall average level of congestion measurement.

Secondly, it may be that these home to work trips within the County use smaller arterial streets, which may also be in reverse flow situations, rather than long-distance radial through routes with greater cumulative congestion levels (e.g., I-270, I-495, etc.).

It also should be noted that the reduction in congestion brought about by adding housing to the JOBS scenario (to produce the FAST scenario) is somewhat greater for the Rail pattern than for the Auto pattern. This is because more of the housing growth in the Rail pattern is located in pedestrian-friendly neighborhoods near transit stations, which thereby yield fewer new automobile trips per household.

Staff is examining the internal aspects of these tests to explore the interpretation of this phenomenon more fully. In the meantime, a preliminary conclusion suggests that, as a very general and abstract proposition, the addition of clustered housing close to employment to a designated level of jobs can produce a traffic reduction effect, on a County-wide basis, potentially equivalent to a reduction of an equivalent number of jobs.

Stated another way, a J/H ratio that is balanced to provide one job for every resident worker (as in the FAST scenario), may indeed be a useful benchmark from a traffic management perspective. This conclusion seems to hold true for both the Auto and Rail patterns, and therefore seems to justify concluding that Proportion is indeed a significant factor with regard to traffic congestion.

Proportion Versus Pattern

Figure 10.1 shows that the congestion reduction from FAST/Auto to FAST/Rail is about three times as great as the reduction from JOBS to FAST in both the Auto and the Rail patterns. Staff concludes, therefore, that not only is the influence of Pace on traffic congestion relatively weak compared to that of Pattern, (as mentioned earlier) but also that the influence of Pattern is considerably greater than that of Proportion.

Effects of Price

Inclusion of the TIE package in the TRAVEL model involves an element of the Price dimension, insofar as it models the effect of changing the relative price of using the automobile versus using transit. The relative importance of this price differential to overall traffic congestion is explicitly noted.

Another element of the Price dimension is undoubtedly also an important determinant of traffic congestion. This is the price of housing. The TRAVEL model does not have, at present, any algorithms that would allow it to simulate the effect on traffic flows of changing the price of housing in different areas. However, the model was calibrated against the traffic flows that are produced by the pattern of housing prices that exists today. To this extent, the model has built in the existing housing price structure of the region.

The difficulty in simulating the traffic effects of alternative future housing price patterns has several aspects. First, housing prices are not just determined by location. They also depend on size and design and construction quality, as well as other factors, such as school district, neighborhood amenity, perceived social image, and relative supply at the time of purchase or rental. Such an array of variables is very complex. Consultants engaged for this study have confirmed that there is at present no model that even adequately explains the relative relationships among these variables, let alone one that could be used to simulate future conditions. Further research by these consultants is proceeding, and it is possible that some new findings about the relationship between housing prices and land use and travel patterns can be forthcoming in the next year or so.

Second, there is no complete data base of the income structure of the workers who occupy the resident jobs in the County. Various employers currently are voicing concern that their lower wage employees cannot find affordable housing in the County, and that the employers encounter difficulty recruiting new employees because of the general price of housing here. But there exists no

inventory of how many of the County's resident jobs fall into various wage level categories. Without such an estimate, it is impossible to mathematically match the income profile of the County's employees against the housing price profile of the County's housing stock. Staff will continue to work on analyzing these relationships, but more data is necessary before any mathematical simulation of alternative future conditions can be undertaken.

Regional Considerations

It is important to point out that the TRAVEL model exercise has demonstrated to staff that the pattern of future jobs and housing growth outside the County's borders exercises considerable leverage over traffic congestion within the County. Although common sense would suggest that the regional pattern will affect the County, the question of how important this aspect is, compared to alternative patterns within the County, can only be assessed by comparing TRAVEL model runs under alternative scenarios for the region.

Because staff effort was focused first on comparing the internal County scenarios, further model runs are necessary before we can get a better feel for the relative effect of different external patterns of jobs and housing. The assignment of new growth to the rest of the region was extrapolated to the year 2020 from the most recent regional forecasts for 2010 by the Council of Governments' Cooperative Forecasting Process, and consultants were engaged to assist in making these assignments as reasonable as possible. However, more work must be done before the relative effect of alternative regional patterns can be seen clearly.

In the meantime, evidence suggests that a major leapfrogging sprawl of jobs into the exurban counties of Frederick, Howard, and even the outer areas of Prince George's County, will add to traffic congestion in Montgomery County under the HOUSING scenario, as will also a major sprawl of housing in these areas under the JOBS scenario. Logic suggests that the best pattern for these exurban areas, from the point of view of Montgomery County, is some variation on the same theme as the RAIL scenario for the County.

An example of the leverage over traffic congestion that is exercised by variation in the regional pattern is shown by the RAIL South Recentralized geographic scenario. Under the FAST economic scenario, this geographic pattern results in a very substantial reduction in traffic congestion from that produced by the FAST/Rail scenario without the South Recentralized land use shift (see Figure 10.1). This shift involved moving some housing from the northern to the southern part of the County, and a major shift of housing from the rest of the region to areas within the District of Columbia and Prince George's County, clustered near Red and Green line Metro Stations (i.e., 70,000 new households to D.C. and 46,000 to Prince George's County.).

Whether such a regional scenario is probable or not, it illustrates the leverage that concentration of land uses

can exercise over traffic congestion if adequate new transit networks are made available. One obvious conclusion is that, although we have not yet modeled the effect of more than just a few alternative regional scenarios, the future of Montgomery County's traffic destiny increasingly will be tied up with that of the rest of the region as time goes on. This is a very important factor that deserves further careful evaluation.

FISCAL IMPLICATIONS

The Modeling Problem

Some generic aspects of the fiscal modeling problem require discussion before examining the results of the fiscal tests of the alternative scenarios. For the traffic tests, we imagine that the scenario is a snapshot of the County at some long range future date, and that we can measure how the transportation system would work, on the average, in the target year whenever it might occur. For the fiscal tests we must make a similar assumption, but there is one relevant difference between the two.

There is less volatility (i.e., a more stable pace of change) in travel behavior than is the case for fiscal behavior. Both the home and work land uses, and the transportation networks, are capital projects which, once installed, exist for long periods of time in the same form. This structural form tends to exercise a very strong influence over traffic behavior.

By contrast, the dominant elements of the FISCAL model have less stable characteristics than is true for those in the TRAVEL model. These FISCAL elements, are composed of monetary flows rather than traffic flows. Monetary flow has very little concreteness or mass. It can move very quickly. More importantly, it is dependent, in turn, on interpersonal transactions that can fluctuate significantly over short time periods, as social mores and demands change in response to felt needs that are not primarily determined by spatial relationships.

For example, the major component of cost in local government is the educational system, which, unlike the dominant part of the transportation system, (i.e., roadways), is heavily labor intensive rather than capital intensive. Changes in relative wage levels, or pupil teacher ratios, can have a major effect on the local government budget without any significant change in the size and location of school buildings. Similar observations apply to health, welfare, and cultural facilities and services. In summary, experience suggests that, barring cataclysmic events, change in travel behavior over time is less volatile than change in the social needs and public service elements that dominate fiscal behavior.

Fiscal Assumptions

In spite of these problems, the scenario exercise requires that we compare alternative scenarios from a fiscal perspective. Therefore, we must make a series of assumptions so that we can compare the net cost and revenue

that would accrue from the alternative scenarios at a given year in the future. Because of this need to make actuarial assumptions about debt service, and because of the need to make demographic assumptions about school children, a particular year (i.e., 2020) was selected for the fiscal evaluation. The snapshot of the County as it would exist under the alternative scenarios in that year was measured in terms of its annual budget, (assuming the same State income tax and County property tax rates as prevailed in 1988); and a determination was made as to whether the budget for the year 2020, under these assumptions, would yield a positive or negative cost revenue balance.

Before examining the results of the fiscal tests, two other factors must be dealt with, factors that have great leverage over whether the cost revenue balance of a local government will be positive or negative. One is on the revenue side and one is on the expenditure side.

Revenue Base Appreciation

On the revenue side we face a major dilemma in determining what to assume with regard to appreciation in real household income and property values over the next thirty years. Over the past thirty years, real appreciation has occurred in both elements, but there are many responsible economists who are predicting that the increasing competition in the global marketplace, and the reduction in apparent productivity on the part of American industry, are leading to a decline in real household income in comparison to other goods and services. At the same time, there are those who argue that we are also witnessing a significant increase in the value of real estate (i.e., relative value compared to income) especially over the last several years.

This is a complex subject on which there does not seem to be any simple consensus, or even a simple model with which to analyze the factors that influence the outcome. For purposes of this study, two alternative possibilities were considered, one called the Sunny Prospect, and the other called the Stormy Prospect.

Revenues Under the Sunny and Stormy Prospects

The Stormy Prospect assumes that there will be no appreciation in either income or property values, in terms of constant dollars, over the next thirty years. The Sunny Prospect assumes that there will be a 1.07 percent per year increase in both income and property values, compounding at an even annual rate for the thirty year period. This is the rate that has prevailed for income in Montgomery County over the past decade. Real estate values have fluctuated, but a case can be made that, in general, real estate values have maintained an appreciation rate at least equivalent to income over the past 20 years or so. Whether property will appreciate more than income in the future can be tested if desired.

State and Federal Funding

A second major variable with a profound effect is the level of state and federal (S/F) funding flowing into the

County. The pass through of grant moneys from these senior levels of government with their stronger income taxing power, historically has been a significant revenue component in the budgets of local governments. There is much public discussion currently about the effect of the enormous federal budget deficit, and whether it will ever be possible for the federal government to return to the level of state and local grants that it enjoyed in the 1960's, or even whether it will be able to maintain the present levels, which are significantly reduced from the former ones.

A significant body of opinion holds that, not only will federal grants to state and local governments decline, but also that the federal government will get out of a number of public service areas and turn these problems over to the local governments, and also that the federal government may go further into taxing sources, such as the sales tax, which have traditionally been the domain of state and local governments.

S/F Funding Under Sunny and Stormy Prospects

For the Sunny Prospect, this study assumes that, in general, state and federal funding to Montgomery County will more closely approximate the situation that prevailed in the early 1970's than the current situation (see Chapter Eight for transportation cost assumptions). The Stormy Prospect simply takes the levels of state and federal funding assumed in the Sunny Prospect and cuts them in half. Whether the values assigned under these two prospects are high enough or low enough is highly speculative. The model can be run relatively quickly to evaluate the effect of alternative assumptions.

Fiscal Implications (Sunny Prospect)

Figure 10.5 shows the results of applying the fiscal model to eight of the combined geo-economic scenarios. Shown as negative amounts, below the zero line, are the expenditure totals for each scenario, divided into three functional categories called School, Other and Transport. Shown above the zero line are the total revenues from all sources for each scenario. Shown on the right of the chart is the net cost revenue balance for each of the scenarios.

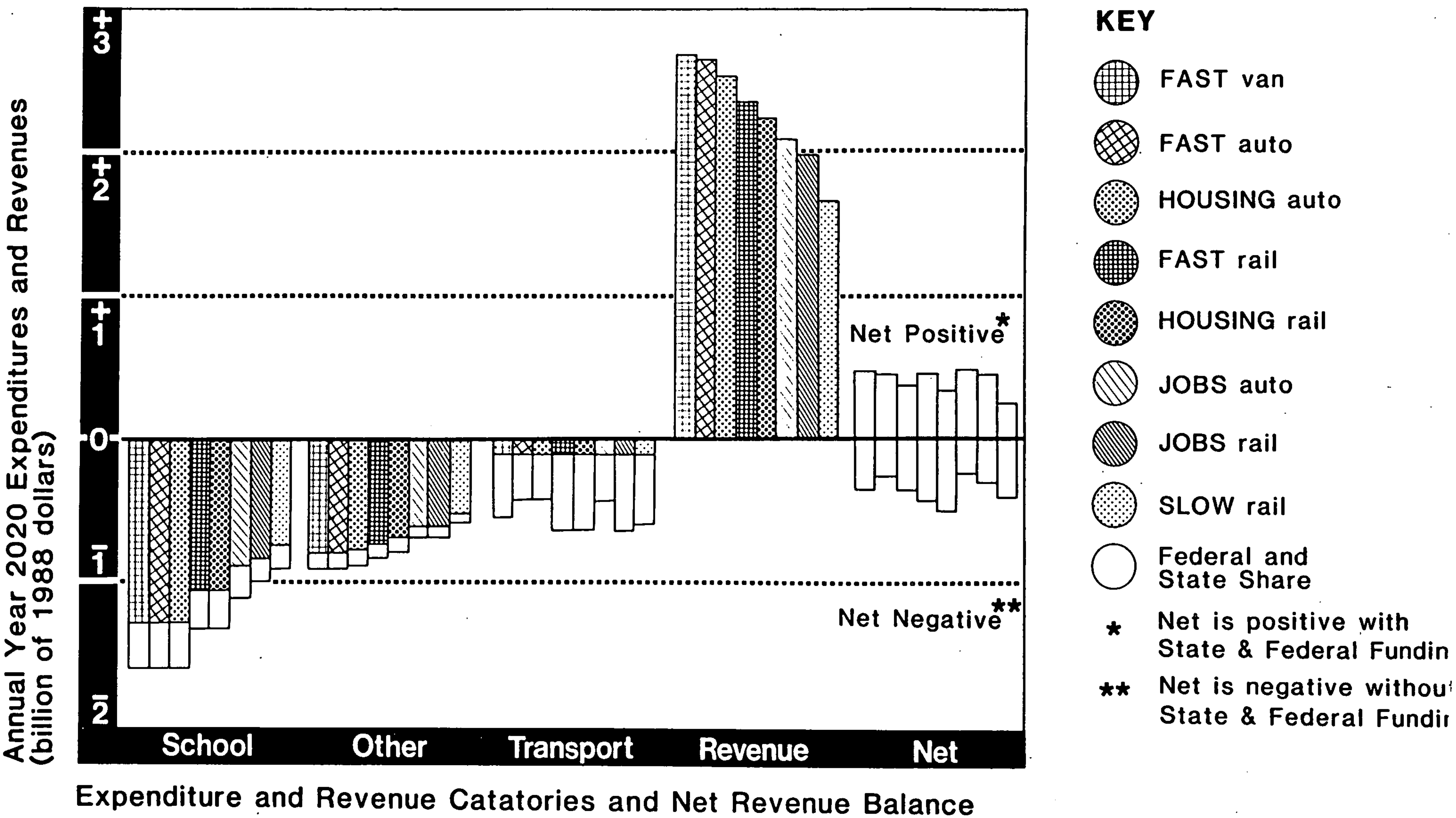
It must be noted here that an expedient device was used in this test to deal with an accounting problem related to the role of state and federal funding. All the scenarios include transportation facilities that are the responsibility of the state to fund and construct (e.g., state roads), and others which have traditionally received S/F grants to supplement the County's expenditures on them (e.g., transit). The latter typically are shown as revenue in the County's annual budget, but the former are not. If the FISCAL model were limited to the latter, the results would not reveal the full role that *total* S/F funding really plays in each scenario.

To overcome this problem, the County's annual budget in the FISCAL Model was simply expanded to include the cost of *all* the transportation facilities, not just the ones that would be eligible for S/F grants to the County.

FISCAL (SUNNY PROSPECT)

EFFECTS OF ALTERNATIVE SCENARIOS
Montgomery County Comprehensive Growth Policy Study

FIGURE 10.5



However, the additional costs for facilities that really are the direct responsibility of the state are indicated, together with the S/F grants to County transportation facilities, separate from the residual costs of these facilities. Therefore, the white portion of the Transportation expenditure bars for each scenario represents the full amount of S/F funding for all the public transportation facilities assumed to exist in each scenario.

In effect, this is equivalent to an assumption that the County would contract with the State to build state facilities and be reimbursed for them. The fact that no additional revenue was added to compensate for the addition of these expenditures is not a problem if the chart is interpreted properly in terms of the meaning of its Net cost/revenue conclusion.

Figure 10.5 shows a net positive balance for all scenarios. But the fact that the bars that show this are all white, rather than patterned, indicates that the entire positive balance is due to S/F funding. The distance to which this white bar extends below the zero line indicates the level of deficit that would occur if *all* the S/F funding assumed for all Transportation, School and Other functions were withdrawn. The distance between the top of this bar on the positive side, and the bottom of the bar on the negative side, is equal to the sum of the S/F portion of the three expenditure bars for the Transport, School and Other categories.

Figure 10.5 illuminates the relative significance of the state and federal funding presence with respect to transportation. On the average, across all the scenarios, the S/F contribution to transportation expenditures is almost double the value of the S/F contribution to school expenditures, and far greater than the S/F contribution to all expenditures in the Other category. Similarly, when considered as a proportion of the transportation total cost, rather than an absolute amount, the S/F contribution is enormously more significant to the Transportation function than is the case for either the Schools or the Other categories.

Seen from this perspective, it is clear how important is the role to be played by the state and federal governments, and particularly by the state government. Indeed on the average across all the scenarios, the total S/F contribution for transportation is about the same size as the amount of the *total* net positive balance that accrues under the Sunny Prospect. It is equal to almost a fifth of the entire revenue amount, on the average across all the scenarios. The role of the state with regard to transportation funding obviously is one of the most critical elements for the County government to evaluate in any long term planning strategy.

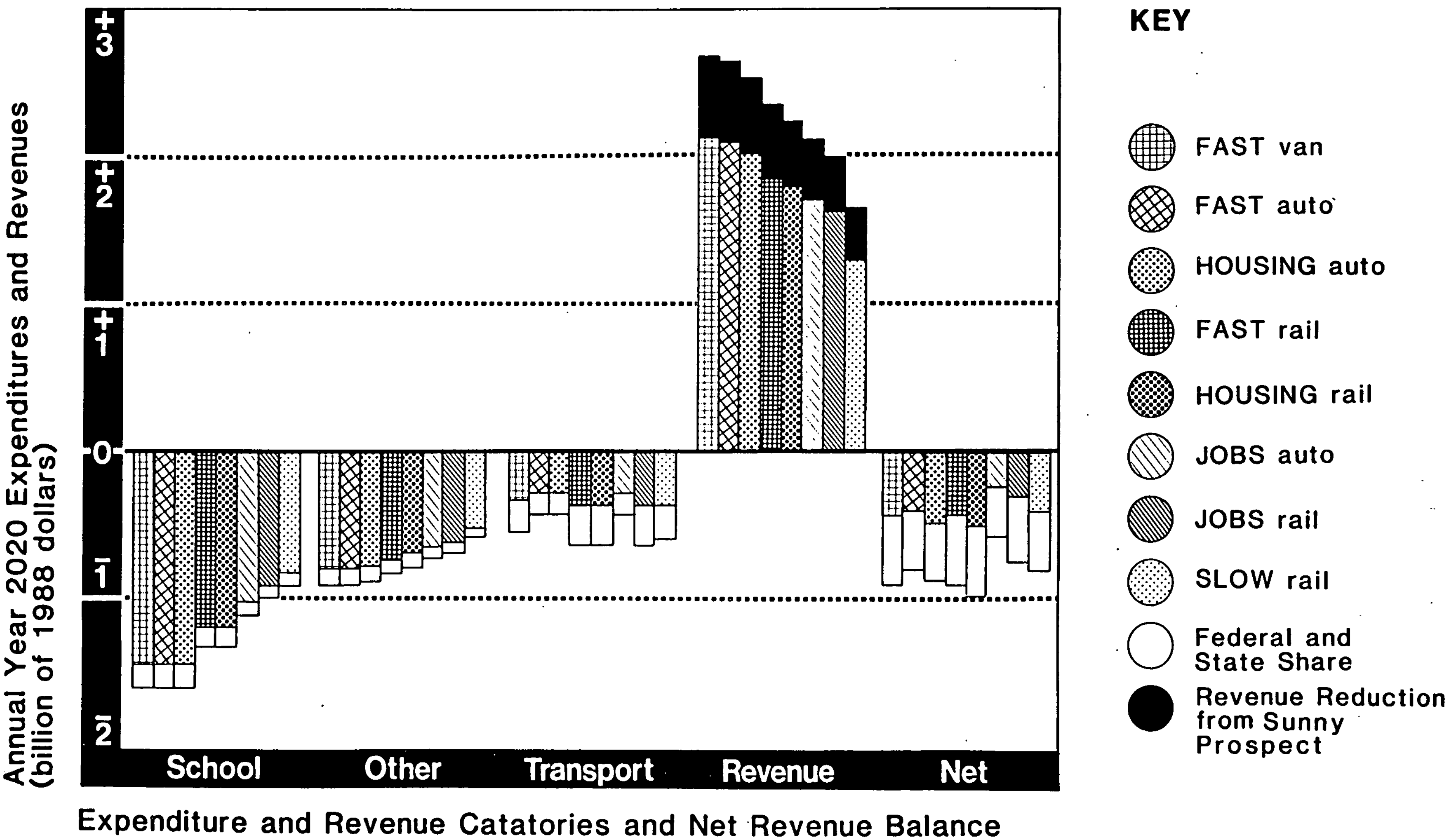
Fiscal Implications (Stormy Prospect)

Figure 10.6 shows the cumulative effect of assuming that federal and state grants are cut in half, and that there is no appreciation in real income and property value. Under this prospect, all the scenarios yield net cost revenue deficits averaging somewhere in the vicinity of 400 million dollars per year. This result is

FISCAL [STORMY PROSPECT]

EFFECTS OF ALTERNATIVE SCENARIOS
Montgomery County Comprehensive Growth Policy Study

FIGURE 10.6



portrayed by the patterned bars below the zero line in the NET column. The white bars below that represent the sum of all the S/F contributions in all three expenditure categories. It shows how much worse the deficit would be if this S/F funding were not available.

It should be noted that one cent on the property tax rate yields about 4 million dollars in revenue in the year 2020 under the FAST/Rail scenario assumptions. A deficit of 400 million dollars, therefore, would be equivalent to an additional one dollar on top of 1988's tax rate. The 1988 rate, for both local property tax and state income tax, was used as the basis for the revenue calculations in these fiscal tests. A one dollar increase in the 1988 property tax rate of $2.17 is an increase in tax rate of 46 percent.

This negative result is the product of the combined effect of the Stormy Prospect's assumptions about both income/property appreciation and S/F contribution, resulting in both a reduction in revenue and an increase in expenditures. Whether both trends would work together with each other is hard to assess.

There is some logic to the idea that an economic situation which results in no increase in appreciation for income and property value would likely be accompanied by a situation in which it would be more difficult for federal and state governments to raise money through taxes, and that, therefore, they might well be disposed to reduce their monetary pass-through (including direct State facility construction) to the local governments under these circumstances.

On balance, it does not seem unreasonable to assume that both the revenue and expenditure trends might work in tandem, in the same direction, leading to the two alternative prospect possibilities, which have been called Sunny and Stormy. Whether the actual targeted numbers used in these two prospect alternatives are appropriate or not is another matter. The numbers were selected for the purpose of providing benchmarks. Other numbers can be selected for testing purposes, to play further "what if" games with the model.

Water and Sewer Costs

Both the Sunny and Stormy Prospect tests exclude the cost of future water and sewer facility needs. Funding to support these facilities is obtained through user charges, which are based on water consumption and administered by the Washington Suburban Sanitary Commission. The cost of these facilities, therefore, does not become a part of the County government's formal budget, and does not enter into the setting of the tax rate. Obviously, it plays a role in the minds of the residents of the County, inasmuch as it affects their household income. But, because its revenue source comes from user fees rather than income or property taxes, a decision was made, for the purposes of this study, to keep it separate.

Chapter 9 contains a description of the County's future water and sewerage needs and their estimated total costs. If these facilities are adequately planned for in advance, and if amortized carefully so as to spread the costs relatively evenly over a long time period, the funding of the necessary additional water and sewerage facilities seems manageable. The question of whether these two assumptions, about (1) planning, and (2) amortizing can be achieved in the real world is another matter that warrants attention as part of the strategic aspect of determining which, if any, of these scenarios can and should be used as the basis for planning purposes.

Pattern, Pace, Proportion and Price

Figures 10.5 and 10.6 show that alternative scenarios do have different cost and revenue characteristics. Most importantly, however, they reveal how swamped are the net cost/revenue differences between scenarios by the tidal wave effects that are created by the alternative Sunny and Stormy Prospects. Clearly the fate of the County is far more a captive of external factors in the case of fiscal effects than in the case of traffic effects. The difference is even greater when we consider that the external forces affecting traffic are regional, and therefore potentially subject to some influencing by the County; but the external forces affecting fiscal are national, or even international, and therefore much more difficult for the County to influence.

Although this is true, it remains of interest to determine whether there are significant fiscal conclusions to be drawn from the alternative scenarios, and whether the relative importance of the dimensions of Pattern, Pace, Proportion and Price can be determined. To assess this, a third prospect was assumed, called the Hazy Prospect. This combines the expenditure assumptions of the Stormy Prospect (i.e., reduced state and federal funding) with the revenue assumptions of the Sunny Prospect (i.e., one percent per year appreciation in income and property value). Using this prospect as background, another fiscal test was run for the purposes of comparing the fiscal differences between each of the alternative scenarios. Figure 10.7 illustrates the results.

Figure 10.7 also shows the cumulative effect of combining the results of the traffic tests and the fiscal test. In this chart, the vertical axis is the same as it was in Figure 10.1, which showed the results of the traffic test. Each of the nine scenarios shown in Figure 10.7 has the same location on this vertical axis of traffic congestion as it did in Figure 10.1. What is different about Figure 10.7 is that the horizontal axis is now the fiscal axis, and the scenarios are located in relation to the level of net cost revenue they yield.

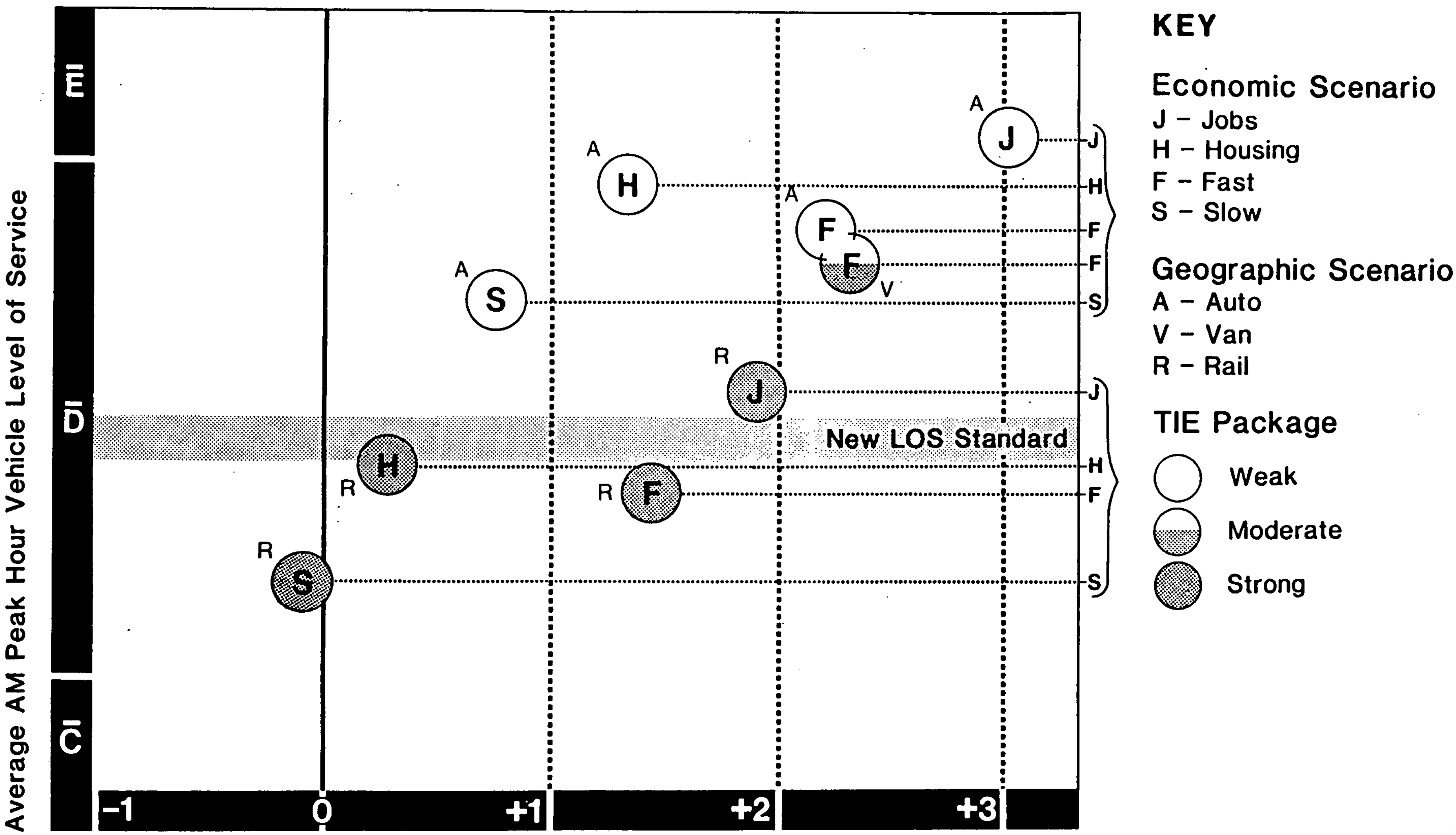
It happens that most of them show a positive net revenue balance, but that is really irrelevant to the main purpose of this particular chart, which is primarily to compare the relative fiscal position of the alternative scenarios when seen at close grain. It was observed above that the uncertainty aspects of the alternative Sunny or Stormy Prospects represent the equivalent of huge tidal waves that may swamp any fine-tuned dis-

TRAFFIC/FISCAL [HAZY PROSPECT]*

EFFECTS OF ALTERNATIVE SCENARIOS

Montgomery County Comprehensive Growth Policy Study

FIGURE 10.7



Annual Year 2020 Net Revenue Balance **(100s of millions of 1988 dollars)**

* Combines Stormy Prospect Expenditure Assumptions with Sunny Prospect Revenue Assumptions

tinctions between alternative scenarios in terms of real world outcomes. Nevertheless, it remains of interest to attempt to hold the effect of these tidal wave uncertainties to a constant value in order to see if any insights can be gained about the fiscal effects of the alternative scenarios from a Pattern, Pace, or Proportion perspective.

Pattern

All the Auto scenarios yield a more positive net cost/revenue balance than do their counterpart Rail scenarios. Presumably this is a direct result of the extra costs for the new rail networks and TIE package changes in the Rail scenario. The difference between them, on the average, is about $100 million, or the equivalent of a property tax rate of about 25 cents under the FAST scenario. It should be noted that potentially offsetting revenue-generating elements of the TIE package, such as a County parking excise tax, were not included in the FISCAL analysis.

Pace

Under both the Auto and Rail patterns, the SLOW scenario yields about $150 million less in net cost/revenue than does the FAST scenario (i.e., about 38 cents on the FAST scenario property tax rate). Both have the same proportion of jobs to housing units, and the same transportation costs. This difference is primarily due to the lower revenue in SLOW compared to that in FAST.

One could conclude that Pace is more important than Pattern from a fiscal perspective, since this difference is about 50 percent more than that which is revealed between the Auto and Rail scenarios. Of course, this conclusion really was built into this scenario, since both SLOW and FAST assume the same transportation costs but have very different revenue bases. We conclude that Pace, therefore, cannot be evaluated fiscally by itself. It must always be linked to the quality, or level of service, component. When this is held constant, the fiscal effects of slower or faster growth tend to become neutral, except for effects that arise due to the "lumpiness" of facility construction and the nature of debt repayments. Although these are important in the short term, they are less so in the long term.

Proportion

Under both the Auto and the Rail pattern, the JOBS scenario yields about $160 million more per year than does the HOUSING scenario (i.e., about 40 cents on the FAST scenario tax rate). The fact that this spread is the same for both the Auto and the Rail patterns reflects the fact that the primary element that accounts for the difference is the number of school children, which is much greater in the HOUSING scenario than in the JOBS scenario, simply because of the existence of many more houses in the former than in the latter.

What is interesting here is the fact that the JOBS scenario has exactly 150,000 more jobs and 150,000 fewer housing units than the HOUSING scenario. The shift

from the one scenario to the other may be thought of as a conversion of one job for one house, up to a total conversion of 150,000 units. Comparing this number to the net fiscal difference between the two scenarios, $160 million, produces a ratio of about $1000 per year per conversion. Thus, although the overall fiscal difference between the two scenarios is large, the marginal difference between a few jobs versus a few housing units is relatively small.

It seems reasonable to conclude that, from a fiscal perspective, there is little to be gained by a close grained monitoring of the status of the J/H ratio on a County-wide average basis. Although large County-wide ratio changes will have a fiscal effect, what will be more important on the margin is the nature and value of individual jobs and housing units. For this purpose, the Residential and Employment Development Impact (REDI) fiscal model is a more useful tool.

Price

As mentioned in the traffic analysis, inadequate data exists to make a finding concerning the relevance of price structures. The FISCAL model assumes a continuation of the relative price relationships among residential and employment properties, by structure type and sub-area, as exists today. (See Chapter 7.) Further staff work will be done on this subject.

Pattern versus Proportion

Discounting the effects of Pace and Price for the reasons mentioned above, the comparison between the effects of Pattern and Proportion shows that the extra cost of moving from the Auto to the Rail pattern is only half as much as the extra cost of moving from the JOBS to the HOUSING scenario. This suggests that the relative fiscal cost of a major shift in travel behavior, from private auto to public transit, is significantly less expensive than the relative fiscal cost of a major shift in the J/H ratio towards housing.

Stated another way, the costs of schools are still more than twice the costs of transportation, on the average, for most of the scenarios analyzed. (See Figure 10.6.) Therefore, a major investment in transportation appears to be a fiscally less expensive way to handle traffic congestion than is a major shift from jobs towards housing (which the traffic tests indicated also has an alleviating effect on traffic).

TRAFFIC AND FISCAL EFFECTS COMBINED

Opposing Tendencies

Figure 10.7 permits us to compare the relative effects of alternative scenarios along the traffic axis and the fiscal axis simultaneously. The first simple combination observation is that the scenarios all fall along a diagonal line that runs from the lower left to the upper right, a direction that moves from low to high traffic congestion and

from low to high net revenue. Thus the scenarios at the extreme ends of this line perform well under one criterion but poorly under the other. Clearly, what is best for the County's fisc is worst for its traffic, and vice-versa.

Opposite Extremes

The JOBS/Auto scenario produces $300 million per year (or 75 cents on tax rate for FAST/Rail scenario), more than the SLOW/Rail scenario, but is almost a full level-of-service category higher in terms of traffic congestion. The JOBS/Auto scenario tests the outer bounds of the general direction in which the County has been heading since about 1970. It produces a level of traffic congestion that clearly will be unacceptable politically and also will create traffic problems of a serious nature.

Although it probably would take 40 years or more to come about, and is highly unlikely to occur simply because of the effect of market forces working against such a high concentration of the region's jobs in Montgomery County, the JOBS/Auto scenario demonstrates that the County cannot afford to stay on the track it has been on for several decades without ultimately encountering serious traffic problems, even although there is some fiscal gain involved.

At the opposite end of the spectrum, the SLOW/Rail scenario keeps traffic congestion at a level roughly comparable to that of today, but yields $300 million per year less in revenue. Just as the JOBS/Auto scenario is highly improbable in the real world in terms of its traffic dimension, so also the SLOW/Rail scenario is highly improbable in the real world in terms of its fiscal dimensions.

The SLOW scenario is roughly equivalent, in terms of Pace, to slowing the job growth rate to about 40 percent of that experienced on the average over the last 30 years, and the housing growth rate to about 60 percent of the housing average over the same period. If such a slowdown were also regional, it seems unlikely that enough pressure would exist to support the major investment in transit, and concentration of land use, that allow this scenario to yield such a low level of traffic congestion. Without this level of investment and commitment, the SLOW scenario would stay in the Auto pattern with far greater levels of congestion.

Of course much of this congestion is the consequence of SLOW/Auto scenarios' assumption of growth continuing to occur at a high level in the rest of the Metropolitan region, with its traffic effects spilling over into Montgomery County. In essence, the SLOW/Auto scenario tests a situation in which Montgomery County is assumed to be able to slow its growth deliberately while other jurisdictions do not. Under an assumption of high regional growth, the question for the SLOW/Rail scenario then becomes one of whether it is likely that Montgomery County could pay for such a transit investment as the Rail pattern requires.

Although this could be possible, it seems unlikely. Would the state government contribute as much to Montgomery County as even the "Hazy Prospect" assumes, if such a slowdown were deliberately engineered by the County, with its corollary effect of reducing the growth in state income tax from this area? In the event that the state did not contribute to the transportation investment necessary, the County would have to raise taxes for this purpose. One can speculate that this could happen but it seems unlikely.

Staking Out the Middle Ground

Obviously a position in between the two extremes described above is the logical compromise, a position where traffic congestion is kept to as low a level as can be balanced against an acceptable net cost/revenue position. The problem is how to find the "sweet spot" where the optimum trade-off is achieved. What would really be desirable would be a trend line connecting scenarios that ran in the opposite direction from the dominant trend line of this group of scenarios, a line that ran from the upper left side of Figure 10.7 to the lower right side. Every move to the right along such a line would both reduce traffic congestion and increase fiscal revenue.

Figure 10.7 reveals that a line drawn between the SLOW/Auto scenario and the FAST/Rail scenario would run in this direction. The SLOW scenario is the closest of all the scenarios to the County's actual position today, in terms of total number of jobs and housing units, whereas the FAST scenario is the farthest away. (See Chapter 1, Figure 1.2.) As long as economic growth continues in the County, the County must inevitably move past the SLOW scenario in the general direction of either the JOBS, HOUSING, or FAST scenarios.

An imaginary line linking SLOW/Auto to FAST/Rail is a useful device, because it helps us to see that the optimum growth path on which to maintain balance between traffic and fiscal constraints is to move not only from SLOW towards FAST, maintaining a balanced J/H ratio along the way, but also from Auto to Rail as well.

We conclude that this mathematical scenario-testing exercise confirms a common sense vision that: (1) we must move away from an auto dominated travel pattern towards the RAIL pattern, with its equal balance between the auto and other modes, and that (2) we must move away from a job dominated economic pattern towards a pattern that balances jobs and housing. A balanced jobs/housing economical ratio and a balanced driver/non-driver travel ratio seem to work together better than any other combination. Conceptually, it seems that a broad policy goal can now be set against two mathematical benchmarks: (1) a jobs to housing unit ratio that provides one resident worker for every resident job (i.e., about 1.5 in today's labor market), and (2) a driver to non-driver ratio that provides one alternative mode trip for every driver trip (i.e., about 1.0). How to test these goals against reality and change over time now becomes the challenge.

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Consultant Credits

Name of Firm	Nature of Work
COMSIS Richard Kuzmyak C. Y. Jeng Ron Malone Richard H. Pratt	Transportation Modeling
DeLeuw, Cather and Company Clarke Rees	Transportation Analysis and Cost Estimating
Douglas & Douglas, Inc. Bruce Douglas, Ph.D Barry Zimmer	Transportation Modeling
Greater Washington Research Ctr. George Grier	Demographic Analysis
Hammer, Siler, George Associates Elizabeth Davison	Housing Analysis
JHK & Associates Morris J. Rothenberg	HOV Analysis and Costing
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